CHAPTER

13

UNDERSTANDING AND SUPPORTING WINDOWS NT WORKSTATION

In this chapter, you will learn:

- About the Windows NT environment and its architecture
- About the strengths and weaknesses of Windows NT
- How to evaluate when Windows NT is the best choice for a PC OS
- How to install and customize Windows NT
- How to set up a Windows NT environment for a DOS or Windows 3.x application
- How to use some Windows NT troubleshooting techniques and tools

This chapter provides an introduction to Windows NT Workstation (the NT stands for new technology), including basic architecture, installation, maintenance, and troubleshooting. There are two versions of Windows NT: Windows NT Workstation and Windows NT Server. You can use Windows NT Workstation on a standalone PC or as the operating system on a workstation connected to a network. Windows NT Server, which is not covered in this book, can do the same, as well as provide a domain environment on a network. (A **domain** is a group of computers joined together over a network that share a common database used to control security to each PC on the network.) There have been several upgrades of Windows NT; the last is Version 4, which is the subject of this chapter. The next upgrade of Windows NT is Windows 2000, which is the subject of the next chapter although many of the concepts, processes, and tools introduced in this chapter also apply to Windows 2000.

Windows NT Workstation and Windows NT Server are architecturally built more like the UNIX OS than like other Windows operating systems, such as DOS with Windows 3.x and Windows 9x. Windows NT is designed with a strong emphasis on room for expandability, primarily accomplished by its modular approach to dealing with applications and hardware. Windows NT is also intended to port to several non-Intel-based platforms, provide a high level of security, performance, and reliability, and offer strong networking features.

Assuming that you are familiar with Windows 9x, this chapter often compares Windows NT Workstation to Windows 9x so that you can contrast them and make informed decisions about which best suits your needs. However, comparisons of some features are difficult to make because the two operating systems are fundamentally different. It would be much easier to compare Windows NT to UNIX, particularly when talking about performance, reliability, and networking features. Traditionally, UNIX has not been a viable option for a personal computer operating system, although this is changing somewhat with the growing popularity of Linux. This chapter only compares Windows NT to Windows 9x. Furthermore, to fully appreciate the strengths of Windows NT, you need to go beyond the scope of this chapter to studying networking in detail.

Windows NT vs. Windows 9x

Table 13-1 summarizes how some important Windows NT and Windows 9x features (which will be discussed in this chapter) compare. Remember the following two important points: First, if Windows NT is installed on a PC that is not as powerful as the type of computer it was designed to run on, Windows NT does not perform as well as Windows 9x would on that PC. However, on a powerful workstation PC with a configuration recommended for Windows NT, Windows NT usually performs faster and better than Windows 9x. The second important point is that Windows NT is not another evolution of DOS, Windows 3.x, and Windows 9x. In fact, the opposite is true. Windows NT was developed before Windows 95. Windows 9x and its upgrade, Windows 98, were built as a bridge between the old (DOS with Windows 3.x) and the new (Windows NT). The rest of this section highlights and expands on several of the differences between Windows NT and Windows 9x. While Windows 9x and Windows NT Workstation differ dramatically in underlying architecture and structure, they share many features, including a similar user interface, some of the same utilities (such as Internet Explorer and Microsoft Messaging), and other features (such as system policies, user profiles, and hardware profiles). Windows NT Workstation offers higher performance, reliability, and security than does Windows 9x. On the other hand, Windows 9x has less demanding hardware requirements, offers broad application and device compatibility, and works well on notebook PCs because of better power management features and Plug and Play capability.

The key to appreciating the advantage of Windows NT over Windows 9x is in the platforms and settings that Windows NT targets. Windows NT is designed to satisfy the needs of powerful workstations networked in a corporate environment. Windows 9x, however, is used on low-end PCs dominating the home market, where multimedia applications software and ease of installation are more of an issue than network security and high-end performance.

One major difference between Windows 9x and Windows NT is that Windows NT is a full 32-bit operating system, operating in protected mode as soon as it receives control from BIOS. Recall that Windows 9x begins the boot process in real mode and loads some real-mode components before shifting to protected mode. Windows 9x supports real-mode device drivers; Windows NT does not allow them. Windows 9x uses virtual device drivers (VxDs) that often interact directly with hardware. Windows NT does not allow them, but

uses a more layered approach. It does use virtual device drivers, which it calls VDDs, but they are allowed to work only within their virtual machine and must depend on Windows NT device drivers to communicate with the device itself. Table 13-1 lists major differences between Windows NT and Windows 9x.

Table 13-1 Comparing Windows NT to Windows 9x

Feature	Windows 9x	Windows NT
Hardware requirements	Low, requiring a 486 PC with 8–16 MB of RAM	High, requiring a Pentium with 16–32 MB RAM
Hardware compatibility	Supports most legacy devices	Supports most current devices, but does not claim backward compatibility with legacy devices
Software compatibility	Fully backward-compatible with older DOS and Windows 3.x applications	No support for any application that attempts to access hardware directly
Installation	Offers Plug and Play capability	Does not offer Plug and Play and offers less device driver support
Power management	Built-in power management for laptops	None
Performance	Offers multitasking for 32-bit and 16-bit applications	Also offers preemptive multitasking for 32-bit applications and cooperative multitasking for 16-bit applications. Has significantly better performance on systems with at least 32 MB of RAM
Reliability and stability	Much better than Windows 3.x	Very high reliability and stability; all applications run in protected memory space
Security	Allows violation of the logon process controlled from a server	Very high security down to the file level

Features of Windows NT

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Windows NT Workstation includes the following features:

- **Desktop performance.** Supports a powerful multitasking environment and multiple microprocessors for true multitasking
- **Hardware profiles.** Can maintain separate hardware profiles for different hardware configurations on the same PC
- **Internet Explorer.** Provides a built-in web browser (Internet Explorer)
- **Peer Web services.** Provides a personal web server
- **Security.** Provides security for individual files, folders, and other resources. User access to a PC's resources can be controlled by user IDs and passwords on the standalone PC or managed from a network controller.

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- **OS Stability.** Uses protective processing, which prevents applications from causing errors in other applications or in Windows NT itself

Many of these same features, including Internet Explorer, hardware profiles, and user access, are available from Windows 9x as well. Windows 9x allows you to use more hardware devices than does Windows NT, has a simpler installation process, and supports power management features better than does Windows NT. Windows 9x supports Plug and Play technology, but Windows NT does not. Windows NT has higher performance, including faster speed on high-end PCs, higher reliability, and better security than does Windows 9x. The minimum hardware requirements for Windows NT on an IBM-compatible PC are listed below. However, even though Windows NT does run on this minimum hardware configuration, remember that you need a powerful high-end PC to experience the full benefits of Windows NT.

- Pentium-compatible processor or higher
- 16 MB of RAM (32 MB is recommended)
- 110 MB of hard disk space

While the minimum requirements listed above reference IBM-compatible machines, Windows NT can run on other computers as well, providing the same interface and functionality. The main difference between Windows NT running on an IBM-compatible CPU and Windows NT on other computers is in the layer (which is a part of Windows NT) between the OS and the hardware, called the **hardware abstraction layer** or **HAL**. The hardware platforms supported by Windows NT are listed below. This chapter focuses only on the Intel-based CPUs of IBM-compatible machines.

- Intel x86-based (486 or higher) processor
- MIPS R4x00-based processor
- Alpha AXP-based processor
- PReP-compliant PowerPC-based processor

The Windows NT CD-ROM contains three installation directories to choose from, one for each of these types of processors. Each directory contains a different version of HAL (sometimes referred to as the core of the OS). HAL is discussed at greater length later in this chapter.

Hardware Supported by Windows NT. Many hardware device models are not supported by Windows NT. For this reason, before you decide to upgrade a PC to Windows NT, first determine if all components on your PC will work under Windows NT. For instance, you might have to replace a network card, modem, video card, etc., before Windows NT works. To determine if a hardware component is supported by Windows NT, see the **hardware compatibility list** (**HCL**) for Windows NT that comes with the software. The most recent copy is available on the Microsoft Web site at *www.microsoft.com/hcl*. On the list, which you can search by hardware category and/or company name, are all hardware devices supported by Windows 98, Windows NT, and Windows 2000. For instance, Figure 13-1 shows the partial results of a search for modems compatible with Windows NT 4.0. If a device is not on

the list, ask the manufacturer if there is a driver specifically for Windows NT (not just Windows 9x). If no driver exists, this device will not work under Windows NT.

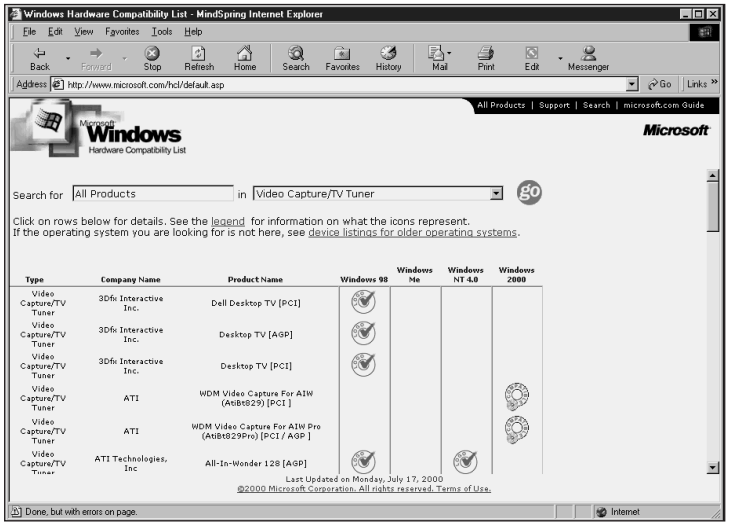

Figure 13-1 Some video capture cards compatible with Windows NT from the HCL

The Windows NT Desktop. Beginning with Windows NT 4.0, the Windows NT desktop took on a similar look and feel to Windows 9x. Figure 13-2 shows the Windows NT desktop with the Start menu and Control Panel showing, both of which work just as they do in Windows 9x, although some Control Panel icons are different. Shortcuts are created the same way as in Windows 9x, and the taskbar works in the same way, too.

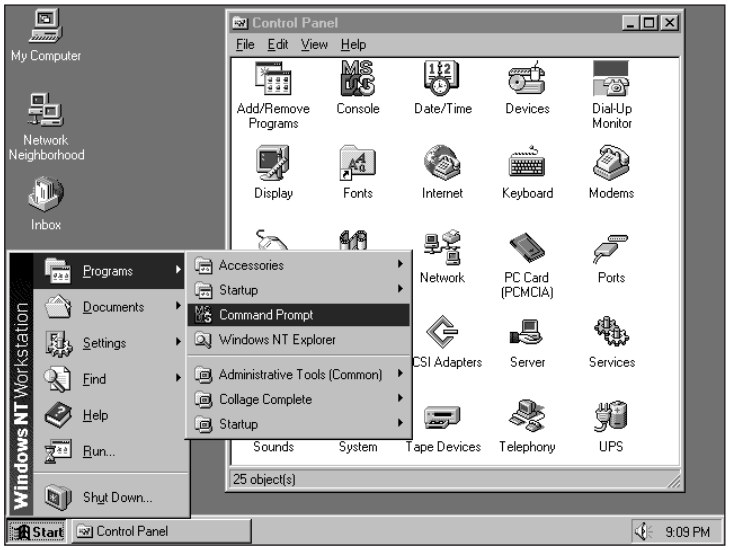

Figure 13-2 The Windows NT desktop is similar to that of Windows 9x

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The Windows NT Command Prompt. Another similarity between Windows NT and Windows 9x is the command prompt that allows the user to enter DOS-like commands. To access the command prompt, click **Start**, **Programs**, and **Command Prompt** (as in Figure 13-2). The Command Prompt window opens, as in Figure 13-3. From the command prompt, you can enter DOS commands. In Windows 9x, the DOS prompt is actually accessing a version of DOS (Windows 9x uses COMMAND.COM at startup). Windows NT, however, provides a DOS command interface primarily as a convenience for those wanting to use familiar DOS commands. There are no DOS programs underlying and running under Windows NT.

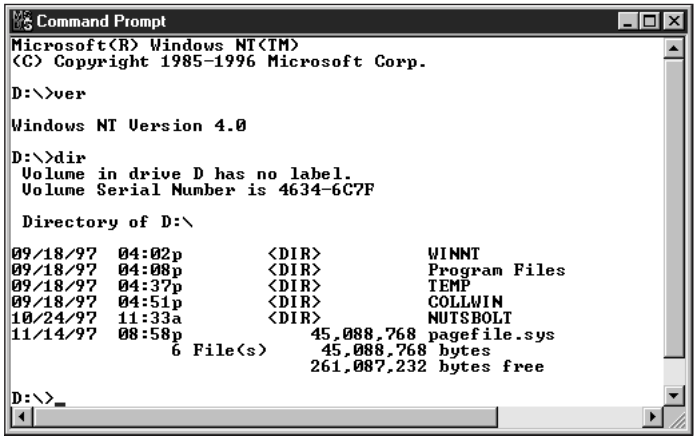

Figure 13-3 The Windows NT command prompt uses DOS-like commands

As a side note, notice in Figure 13-2 that the Control Panel for Windows NT contains an icon, MSDOS, which is labeled Console. Double-click the Console icon to change the properties of the DOS command window. The Console Windows Properties dialog box appears, which allows you to customize the Command Prompt window (see Figure 13-4). If you prefer to use the familiar command prompt often, you can create a shortcut to it by dragging this icon to the desktop.

Choosing Between Windows 9x and Windows NT

When choosing between using Windows 98 or Windows NT as your PC OS, consider the following:

- Does Windows NT support all the hardware devices on your PC? (Check the hardware compatibility list.)
- Is the PC powerful and big enough to support Windows NT? (See the hardware requirements listed earlier in the chapter, and then allow extra resources for your applications.)

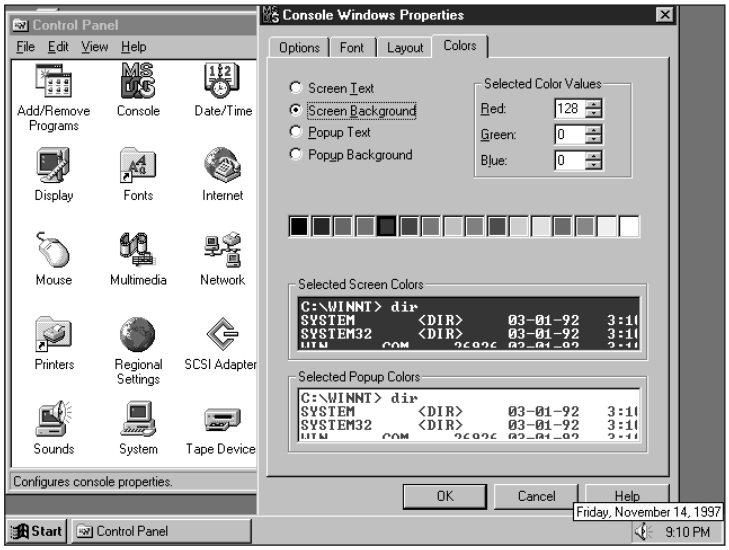

Figure 13-4 Customizing the properties of the Command Prompt window

- Will the software you intend to use on the PC work better under Windows 98 or Windows NT? Running older DOS and Windows 16-bit applications might be a problem in a Windows NT environment. Verify that your current, older software works under Windows NT, or plan to replace the current software with 32-bit versions. Be aware, however, that some 32-bit programs written for Windows 9x might not work under Windows NT because of differences in the API calls to the operating system. (An **API** is an application program interface, which is a method by which one program calls another program to perform a task.)
- Is price a factor? Windows NT costs more than Windows 98.

Upgrading from Windows 9x to Windows NT

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Because Windows NT differs so fundamentally from Windows 9x, there is no automatic upgrade path from Windows 9x to Windows NT. When you change a PC from Windows 9x to Windows NT, you can install Windows NT in a different folder. No system settings in Windows 9x will be transferred to Windows NT. After Windows NT is installed, you must reinstall each application on the PC under Windows NT. Windows NT can be present as the only OS on a PC, or it can be installed on the same PC as Windows 9x. (How to set up this "dual boot" is discussed later in this chapter.)

Registries

The main reason Windows 9x cannot be easily upgraded to Windows NT is that their Registries are not compatible, which makes it difficult to transfer information from one to the other. (Remember that a Registry is a database containing all configuration information for the OS.) You do not have this problem when upgrading from Windows 3.x to Windows NT

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because Windows NT can read the .ini files in Windows 3.x and transfer that information to the Windows NT Registry. Again, realize that Windows NT is not the next stepping stone beyond Windows 98, but a new road altogether.

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A Choice of File Systems

Windows NT can work with two types of file systems: the FAT16 file system, which is used by Windows 9x and its predecessors, and the Windows NT file system (NTFS), which works only with Windows NT. Windows NT does not support FAT32. (Recall that FAT32 was introduced by Windows 95 OSR2 and uses 32 bits for each FAT entry.) Windows NT also does not support the High Performance File System (HPFS) used by OS/2. If a hard drive is using HPFS, use the Windows NT convert.exe utility to convert an HPFS partition to an NTFS partition.

Even though Windows NT 4.0 does not support FAT32, you can use third-party utility software packages to manage the interface, making it possible for Windows NT to read from and write to FAT32.

A **file system** is the method used by an OS to manage the data on a drive. The FAT16 file system is backward-compatible with DOS and Windows 9x and uses less overhead than NTFS. The NTFS file system, on the other hand, is more fail-safe, provides more security, and is more efficient with large hard drives. Below, you see how these two file systems are built and then explore what to consider when choosing between the two.

The FAT16 file system uses four components to manage data on a logical drive: the boot record, the FAT, directories, and data files. In contrast, the NTFS file system uses a database called the master file table (MFT) as its core component. The MFT tracks the contents of a logical drive using one or more rows in the table for each file or directory on the drive. As shown in Figure 13-5, the MFT contains in one record, or row, information about each file, including header information (abbreviated H in Microsoft documentation), standard information (SI) about the file (including date and time), filename (FN), security information about the file called the security descriptor (SD), and data about the location of the file. Entries in the MFT are ordered alphabetically by filename to speed up a search for a file listed in the table. When a drive is formatted for NTFS, each cluster on the hard drive can range from 512 bytes on smaller disks to 4K on larger disks. Clusters are numbered sequentially by logical cluster numbers (LCN) from the beginning to the end of the disk.

Referring again to Figure 13-5, notice that the data area in the MFT record is 2K for small hard drives, but can be larger for larger hard drives. For small files, if the data can fit into the 2K area, the file, including its data, is fully contained within the MFT. For small files, all the cluster information for a file can fit into this one data area, including all the cluster numbers for the file. Each cluster number is stored in a 64-bit entry, compared to either 16 bits for FAT16 or 32 bits for FAT32.

If the file is moderately large and the data does not fit into the MFT, the data area in the MFT becomes an extended attribute (EA) of the file, which points to the location of the data. The data itself is moved outside the table to clusters called runs. The record in the MFT for this moderately large file contains pointers to these runs. Each data run, or cluster, assigned to the

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file is assigned a 64-bit virtual cluster number (VCN). The MFT maps the VCNs for the file onto the LCNs for the drive. This mapping is stored in the area of the MFT record that would have contained the data if the file had been small enough.

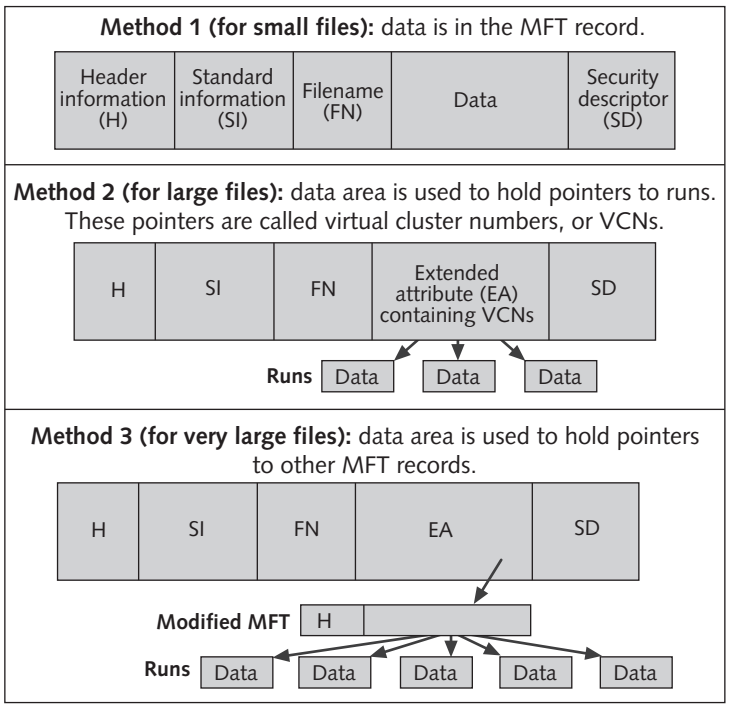

Figure 13-5 The Windows NT file system Master File Table uses three methods to store files, depending on the file size

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If the file is so large that the pointers to all the VCNs cannot be contained in one MFT record, then additional MFT records are used. The first MFT record is called the base file record and holds the location of the other MFT records for this file.

Advantages of NTFS and FAT16 When choosing between the NTFS file system and the FAT16 file system, consider the advantages that NTFS offers over the FAT:

- NTFS is a recoverable file system. NTFS retains copies of its critical file system data and automatically recovers a failed file system, using this information the first time the disk is accessed after a file system failure.
- NTFS offers increased security over the FAT file system. Security is provided for each file, and auditing information about access to files is more complete.
- NTFS supports mirroring drives, meaning that two copies of data can be kept on two different drives to protect against permanent data loss in case of a hard drive crash. This feature makes the NTFS an important alternative for file servers.

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- NTFS uses smaller cluster sizes than does FAT16, making more efficient use of hard drive space when small files are used.
- NTFS supports large-volume drives. NTFS uses 64-bit cluster numbers, whereas FAT16 uses 16-bit cluster numbers. Because the number of bits assigned to hold each cluster number is so large, the cluster number itself can be a large number, and the table can accommodate very large drives with many clusters. NTFS is overall a more effective file system for drives over 1 GB and offers more robust drive compression, allowing compression of individual folders and files.

If the file system for the active partition of a PC is FAT, you can boot from a DOS boot disk and bypass the Windows NT security logon. When you use NTFS, you cannot boot from a DOS boot disk. Use NTFS if you want a high level of security. You can still boot the PC from Windows NT boot disks, but the Windows NT logon is required. In fact, if the one administrator forgets his password to the OS, the only recourse is to reload the OS.

The advantages of the FAT file system over NTFS include:

- The FAT16 file system has less overhead than the NTFS file system and, therefore, works best for hard drives that are less than 500 MB.
- The FAT file system is compatible with other operating systems. If you plan to use either DOS or Windows 9x on the same hard drive as Windows NT, use the FAT file system so that DOS and Windows 9x can access files used by Windows NT.
- In the event of a serious problem with Windows NT, if you are using FAT16 on the active partition of the drive, you can boot the PC from a disk, using DOS, and gain access to the drive.

You can choose to have Windows NT use NTFS by directing it to convert the hard drive from FAT16 to NTFS or by having Windows NT partition a drive so that one partition of the drive uses the FAT format and the other uses the NTFS format. Windows NT allows you to format logical drives with either FAT16 or NTFS on the same extended partition.

Hard Drive Partitions

Windows NT assigns two different functions to its hard drive partitions (see Figure 13-6). The **system partition**, normally drive C, is the active partition of the hard drive. This is the partition that contains the boot record (often called the DOS boot record). Remember that startup BIOS and then the master boot program in the boot sector look to this boot record for the boot program as the first step in turning the PC over to an OS. The other partition, called the **boot partition**, is the partition where the Windows NT operating system is stored. The system partition and the boot partition can be the same partition, or they can be separate partitions. Both can be formatted with either the FAT16 or NTFS. However, only Windows NT can read files formatted with NTFS. If you want another OS to access this hard drive, you must use the FAT16 file system for the partition that another OS accesses.

Recall that Windows 9x, using Fdisk, can create two partitions, a primary and extended partition. The primary partition contains drive C and the extended partition can contain several volumes or logical drives. Also recall that each FAT16 volume can be no larger than 2 GB. Using Windows NT, you can have up to four partitions. The first partition is the primary and can have only a single drive C. One of the other three partitions can be an extended partition, which means it can have several volumes or logical drives. Because of the way Windows NT uses the FAT, each FAT16 volume can be up to 4 GB. The third and fourth partitions in Windows NT can each have a single volume.

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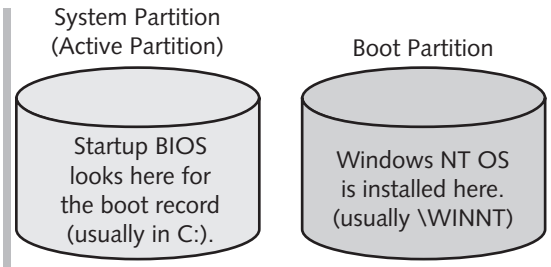

Figure 13-6 Two types of hard drive partitions

Don't be confused by the terminology here. It is really true that, according to Windows NT terminology, the Windows NT OS is on the boot partition, and the boot record is on the system partition, even though that might sound backward. The PC boots from the system partition and loads the Windows NT operating system from the boot partition.

The Dual Boot

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Remember that Windows NT can coexist on the same PC with either Windows 9x or DOS. The ability to boot from either Windows NT or another OS, such as Windows 9x or DOS, is called a **dual boot**. In a dual boot arrangement, the system partition must be FAT rather than NTFS, so that the non-NT OS (Windows 9x or DOS) can read it.

Windows NT cannot access a FAT32 drive without third-party software. If you are using Windows 98 with FAT32 and want to create a dual boot with Windows NT, you must first convert to FAT16 or use third-party software to manage the Windows NT and FAT32 interface. To convert from FAT32 to FAT16, use a utility such as Partition Magic.

Windows NT resides on the boot partition, which can also be formatted for the FAT16 file system and can share the same partition with the other OS or reside on a second partition, such as drive D. You can format this second partition with either FAT or NTFS. If drive D is NTFS, Windows 9x cannot read any data stored on that drive. If drive D is a FAT16 partition, either OS can read data from either drive.

After both operating systems are installed, a startup menu appears, asking which OS to boot (similar to the menu provided when Windows 9x and DOS are on the same PC). The disadvantage of a dual boot is that applications software cannot be easily shared between the two OSs.

The Windows NT Environment and Architecture

Understanding the Windows NT environment and architecture begins with understanding the goals and objectives of Windows NT. This section begins by examining some of the objectives of Windows NT, which helps explain why Windows NT works the way it does. Following that discussion is an examination of how Windows NT accomplishes these objectives.

The Goals of Windows NT

Windows NT was conceived when IBM and Microsoft collaborated in building OS/2. While IBM took over OS/2, Microsoft redesigned and added to the original, calling the new OS Windows NT. The next evolution of the OS was called Windows 2000. Windows NT and Windows 2000 have many of the same objectives as UNIX and are considered the primary competitors to UNIX in the client/server industry. Because Windows NT and Windows 2000 also function on a LAN, they are considered competitors of NetWare software by Novell, which is popular for managing LANs. Finally, Windows NT and Windows 2000 compete for some of the standalone PC market, contending with Windows 9x. In this discussion about the goals of Windows NT, the information given also applies to Windows 2000. For an OS to contend for so many markets, its objectives must, by nature, be many, including the following:

- **Room to grow.** Windows NT is designed for expandability, so it can more easily accommodate new hardware and software. The main way that NT does this is by using a modular approach to performing tasks. For example, remember that one way DOS is limited in allowing an application more memory addresses is that real-mode DOS drivers can access memory addresses directly without going through DOS, and thereby can "box in" an application in the first 640K of memory addresses. (Remember from Chapter 4 that memory beginning just above 640K cannot be allocated to applications.) With Windows NT, this "boxing in" can't happen. Applications are required to pass their requests to NT, which processes them. Because of this layer of protection between software and hardware, when hardware requirements change, Windows NT manages the change; the application is insulated from the change. (However, a disadvantage to this approach is that Windows NT must have an interface to all new device drivers before any application operating under Windows NT can use a new device.)
- **Portability to different platforms.** Because of the Windows NT modular approach, it easily ports to different platforms or hardware configurations, including different CPU technologies. Remember that the Windows NT installation CD-ROM comes with three directories ready to accommodate three different CPU technologies. Windows NT can do this by isolating parts of the OS from other parts in a modular fashion. The part of the OS that interacts with the hardware is the HAL, which is available in different versions, each designed to address the specifics of a particular CPU technology. The HAL is the only part of the OS that has to change when platforms change. The other components of the OS need not be changed when the platform changes.

- **Compatibility with other OSs and legacy software.** Because Windows NT had its beginnings in OS/2, Microsoft is committed to Windows NT being compatible with software written for OS/2. As long as DOS applications don't attempt to access resources directly, they too can run under Windows NT. Windows 3.x 16-bit applications can run under Windows NT in a virtual machine environment similar to a Windows 9x virtual machine (discussed at greater length below). Windows NT also supports **POSIX (Portable OS Interface)** based on UNIX, a set of standards adopted by the federal government to better ensure that operating systems and software can port more easily from one platform to another.
- **Security.** Windows NT provides security similar to that on UNIX systems, which is greater than that found in Windows 9x. Windows NT security allows for: (1) the requirement that a user have a logon ID and password to gain access to the PC, (2) security between users on the same PC, so that one user can block another user from data or software, (3) auditing trails to identify security breaches, and (4) memory protection between different applications loaded at the same time.
- **Performance and Reliability.** Although no OS is faultproof, Windows NT provides a much more stable environment than do many OSs, including Windows 9x. Windows NT is less likely to hang, or "lock up," than are other PC OSs. If an application stalls, other applications also loaded are less likely to be affected. When using powerful workstations, Windows NT outperforms Windows 3.x and Windows 9x when running applications written for Windows NT, Windows 3.x, Windows 9x, and DOS.

The Modular Concept of Windows NT

Here's an analogy to help you understand the modular concept of Windows NT. The idea is to isolate one process from another so that a change in one process has the least possible effect on the other processes. Consider the self-serve restaurant in Figure 13-7. In the process illustrated in Figure 13-7a, customers arrive for breakfast, walk to the back of the restaurant, tell the cook what they want, wait for him to cook it, take it back to a table, and eat. Customers are responsible for getting their own drinks, silverware, etc. What is the flaw in this design? There are many, but concentrate on only one at this time. Suppose someone in the kitchen moves the silverware or installs a new and different drink-dispensing machine. How many people must learn a new process so the system can continue to work? Every customer. This process is nonmodular and clearly does not minimize the effect that a change in one part of the process has on other parts of the process.

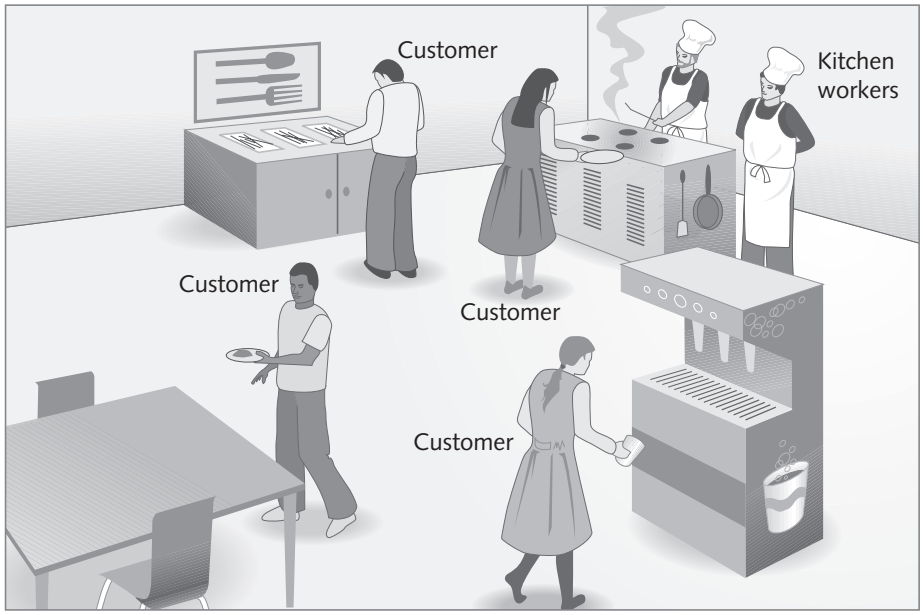

Figure 13-7a In a nonmodular restaurant model, every customer is responsible for many of the steps in the process

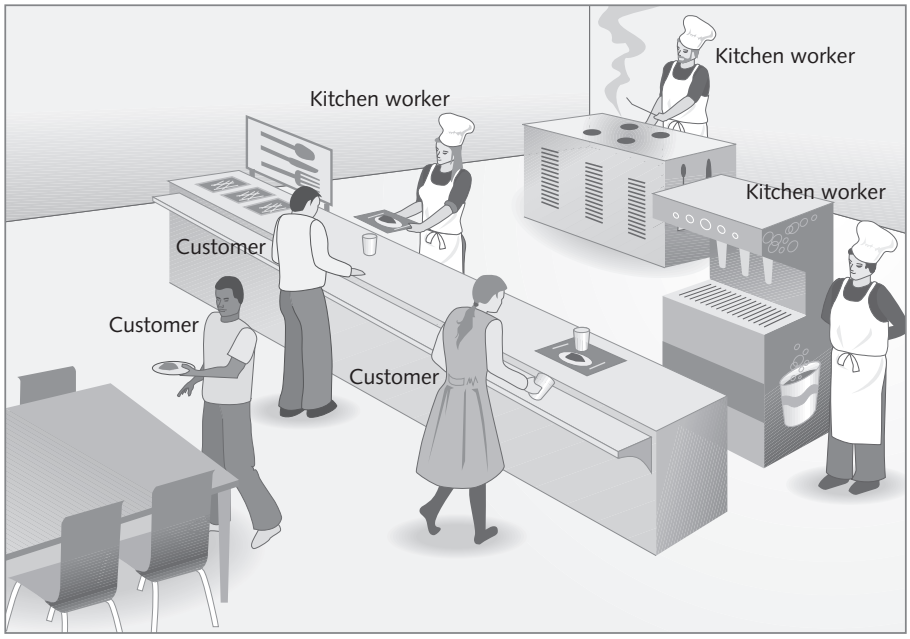

Figure 13-7b In a partially modular restaurant model, customers are isolated from some processes

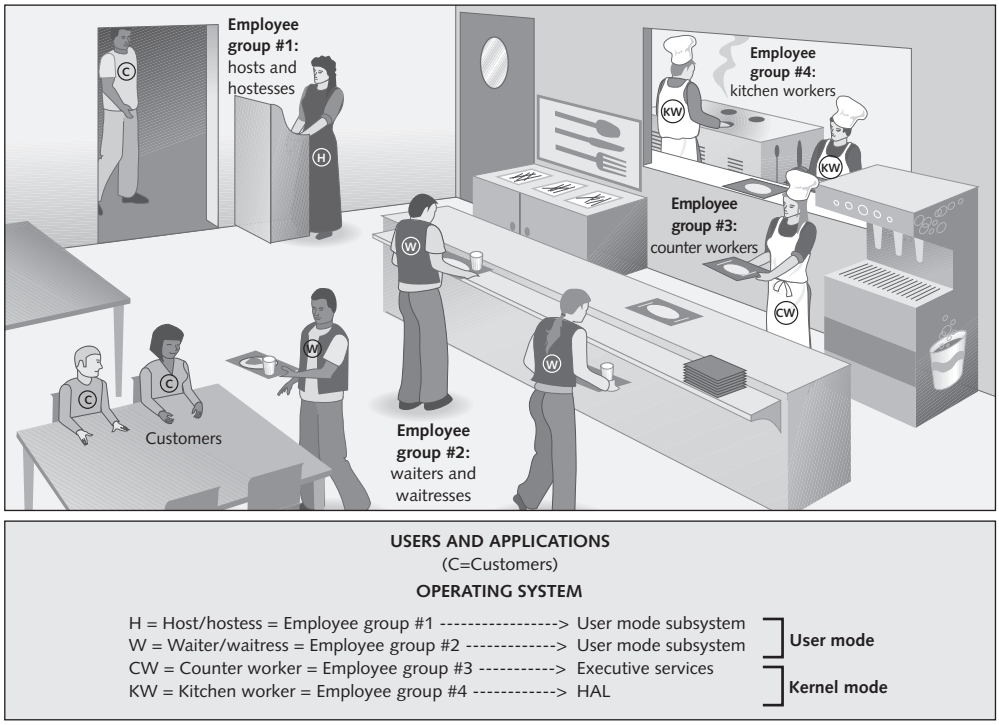

Figure 13-7c In a highly modular restaurant model, employees are grouped by function, and customers interact only with one group of employees. Employee groups are analogous to different parts of the Windows NT operating system

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Now consider Figure 13-7b. A counter has been added, and customers are not allowed behind this counter. They come to the counter and tell others in the kitchen what they want to eat, and someone in the kitchen brings the food, drink, and silverware to them at the counter. Things work a little better now. When processes change in the kitchen, only employees who work in the kitchen must be retrained. However, there is still a flaw in the efficiency of this design. Every kitchen worker must know how to cook and make drinks and where the silverware is located. This model introduces some benefits of a modular design, but still has flaws.

Figure 13-7c further refines the process, and our restaurant is now a full-service, highly modular affair. Employees are divided into four groups, each with a different function. The first and second groups of employees—the hosts and hostesses, waiters and waitresses—interact with the customers, greeting them at the door, showing them their seats, taking orders, and serving food. The second group (the waiters and waitresses) also serves as an interface between customers and counter workers. The third group (the counter workers) stands between the kitchen counter and the customer counter, where the drink machines and the silverware are located. The waiters and waitresses pass food requests to the counter

workers, who pass the requests to the fourth group, the kitchen workers, who now only prepare the food. When the food is passed back to the counter workers, these workers gather up drinks, silverware, and food and pass them on to the waiters and waitresses, who serve the customers. This model uses a more modular arrangement that provides the benefits of separating processes from each other, even though the overhead (the additional resources needed to implement the new model) is higher than in the other models.

What are the advantages of the last model? If the drink machine is upgraded, only the counter workers must be retrained. If the oven or stove in the kitchen is replaced with an altogether new electronic unit, only the kitchen workers change their methods. The counter workers are unaffected. The waiters and waitresses don't need to know how to communicate with the cook, but can focus on customer service. The customer is isolated from the entire process. In comparing Figures 13-7a and 13-7c, on first appearance it looks as though the process has been complicated. There are more workers, and customers now have to wait to be seated. In fact, a new layer of complexity has been added, and two counters are required. However, it turns out that the advantages of the new system outweigh its disadvantages and overhead. Not only can equipment be easily upgraded without having to retrain so many people or reorient customers to the new procedures, but the integrity of the operation is enhanced: because the processes have been separated from each other, they can now be more easily controlled. Standards and procedures can be more easily applied to each segment of the process because fewer people are involved at each step in the operation, which reduces confusion and improves the overall efficiency of the operation. In summary, the three main reasons to use the highly modular model rather than the nonmodular model are:

- To make upgrades of equipment easier (some employees and all customers are unaffected)
- To increase the overall efficiency of the operation (each part of the process involves fewer people than in the other models)
- To better ensure the integrity of processes (standards are more easily enforced)

The process of running the restaurant can be viewed as analogous to the way operating systems run a computer: the modular approach is analogous to the Windows NT OS, and the nonmodular approaches are analogous to earlier OSs. Customers can be viewed as a combination of users and applications software; employees can be viewed as the OS; the stove, drink machine, silverware stand, etc., can be viewed as the hardware; and the cook can be viewed as those parts of the OS that relate directly to hardware, system BIOS, and device drivers. The process illustrated in Figure 13-7a is most analogous to DOS, in which applications were allowed "behind the counter" to interact directly with BIOS and device drivers, and even to perform some of their own operations with hardware, rather than necessarily turning to the OS to perform hardware operations. For example, in DOS, an application program written to address specific hardware configurations might depend on video BIOS always being found at certain memory addresses, and the program could access that BIOS directly.

The process illustrated in Figure 13-7b is most analogous to a model of the Windows 9x OS, because the customers (the applications) are isolated from some of the interaction with the equipment (hardware), but not all. Notice, for instance, that the silverware stand is still

available for customer use; similarly, in Windows 9x, a 16-bit program can interact directly with video memory and other resources.

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The process illustrated in Figure 13-7c is most analogous to the Windows NT OS, which includes an additional layer between the applications (customers) and hardware (the restaurant equipment); applications (customers) are almost completely isolated from interaction with hardware (restaurant equipment). In fact, the Windows NT architecture is divided into two core components called user mode and kernel mode. **User mode** is a nonprivileged processor mode in which programs have only limited access to system information and can only access hardware through other OS services. **Kernel mode** is a privileged processor mode in which programs have extensive access to system information and hardware.

In the Windows NT analogy, the customers represent users and applications. The user mode includes the hosts and waiters, who represent the different subsystems within user mode (see Figure 13-8). The kernel mode is a combination of the counter workers and the kitchen workers. It is made up of two main parts: the HAL (the kitchen workers) and a part called **executive services** (the counter workers). Applications in user mode have no access to hardware resources. In kernel mode, executive services have limited access to hardware resources, but the HAL primarily interacts with hardware.

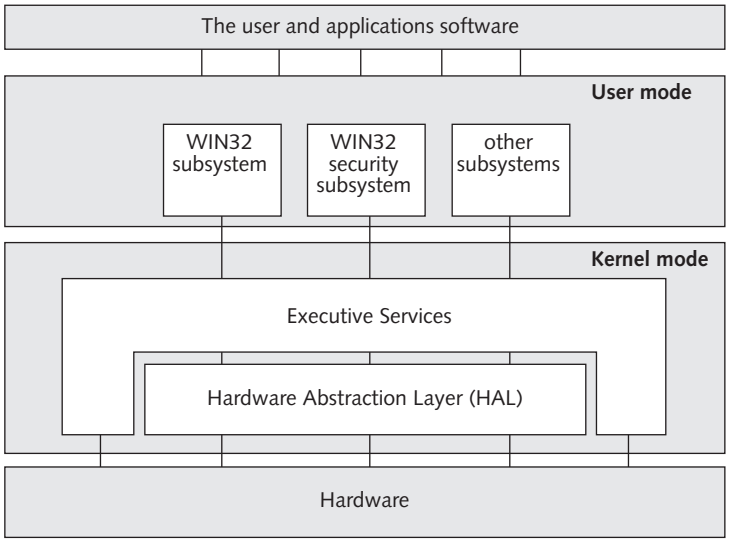

Figure 13-8 User mode and kernel mode in Windows NT and how they relate to users, applications software, and hardware

Windows NT was designed to easily port to different hardware platforms. Because only the kernel mode is actually interacting with hardware, it is the only part that needs to be changed when Windows NT moves from one hardware platform to another. For instance, if a major piece of hardware changes (in the restaurant analogy, a new stove in the kitchen), only the HAL must change. Minor hardware changes might cause changes in executive services. When hardware changes are made, the user mode requires little or no change. When

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hardware improves, even though applications have these new resources available to them, they are not responsible for knowing how to interface with them.

Limiting access to the hardware mainly to the HAL increases system integrity because more control is possible. With this isolation, an application cannot cause a system to hang by making illegal demands on hardware. Overall performance is increased because the HAL and executive services can operate independently of the slower, less efficient applications using them.

On the other hand, it is easy to see why Windows NT requires a much more robust system than does Windows 9x or DOS. The increased overhead of this OS only benefits you when hardware and applications software are hefty enough to take advantage of the more powerful OS.

User Mode

In the restaurant analogy in Figure 13-7c, the purpose of the hosts and waiters is to interact with the customers. The purpose of the user mode is to interface with the user and with applications; what you view when running Windows NT is primarily running in user mode. User mode is divided into different modules called **subsystems**. There are two kinds of user mode subsystems, which are defined by their functions. **Environment subsystems** provide an environment for an application to run in; consider an environment subsystem a virtual machine, because it provides a total and complete environment for an application, and, in effect, places the application in "its own little world." One example of a program that is part of the environment subsystem is Explorer. The second group of subsystems is the **integral subsystems**, which are used to provide services to the rest of the system. An example is the security subsystem serving other subsystems by handling the security for files and folders. The Windows NT logon screen belongs to this security subsystem.

In Figure 13-8, note the Win32 subsystem, an environment subsystem, which is probably the most important user mode subsystem because it manages all 32-bit programs and provides the user interface (for example, Explorer). (Remember from Chapter 12 that 32-bit programs are programs written for protected mode using 32-bit code.) The Win32 security subsystem is an integral subsystem and provides logon to the system and other security functions, including privileges for file access. Other subsystems might or might not be running.

All environment subsystems must relate to the executive services by way of the Win32 subsystem, which is itself an environment subsystem. Figure 13-9 shows how various programs that run under Windows NT interact with subsystems. For instance, each DOS application resides in its own **NT virtual DOS machine (NTVDM**), an environment where a DOS application can only interface with this one subsystem, and cannot relate to anything outside the system. All the 16-bit Windows 3.x applications reside in one NTVDM called a **Win 16 on Win 32** (**WOW**) environment. Within the WOW, these 16-bit applications can communicate with one another, and they can communicate with the WOW, but that's as far as their world goes. Because Windows 3.x is itself a DOS application, it must reside in an NTVDM. Figure 13-9 shows three 16-bit Windows 3.x applications residing in a WOW that resides in one NTVDM. Because DOS applications expect to run as the only application on a PC, each has its own NTVDM.

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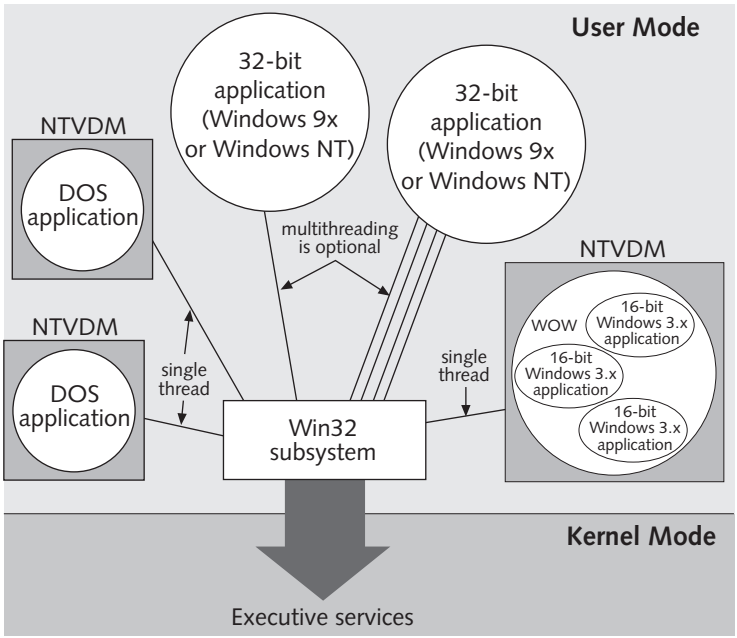

Figure 13-9 Environment subsystems in Windows NT user mode include NTVDMs for DOS and Windows 3.x applications and optional multithreading for 32-bit applications

You can see in Figure 13-9 that 32-bit applications do not require an NTVDM and can relate to the Win32 subsystem directly, because they are written to run in protected mode. The figure shows that 32-bit applications can also use a single line of communication (called single threading) with the Win32 subsystem or can use multiple lines for interfacing (called **multithreading**) with the Win32 subsystem, depending upon what the application requests. An example of multithreading is an application request that the subsystem read a large file from the hard drive while performing a print job at the same time. Single threading happens when the application does not expect both processes to be performed at the same time, but simply passes one request followed by another.

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Kernel Mode

Remember that the kernel mode of Windows NT includes executive services and the HAL, which interface more directly with the hardware than does the user mode. Figure 13-10 expands the information from Figure 13-8 to show several of the components of the executive services portion of the kernel mode. Most interaction with the hardware is done by executive services passing the request to the HAL. However, from the diagram, you see that executive services includes device drivers, which have direct access to the hardware.

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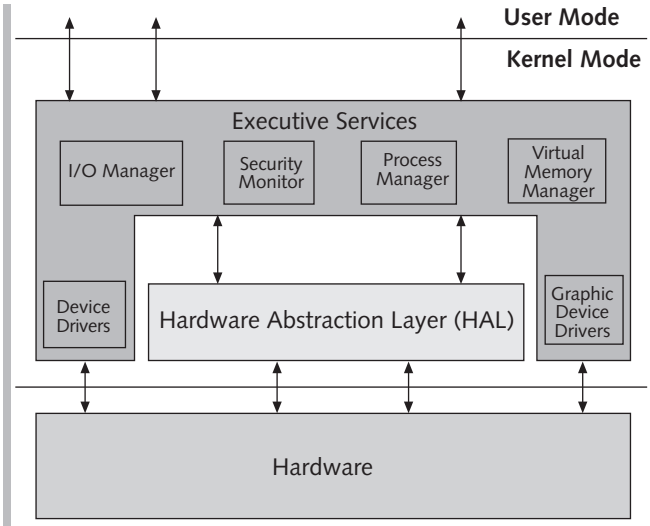

Figure 13-10 Components in the Windows NT kernel mode relate to subsystems in user mode and relate to hardware

Only kernel mode components can access hardware. However, in DOS, applications can access hardware resources directly, or they can use an API call to ask DOS to perform the task. In Windows NT, if a DOS application tried to directly access the printer port LPT1, Windows NT would shut down the DOS application. But if the DOS application tried to access the printer by passing a DOS API call to the Windows NT NTVDM, it would be allowed to proceed.

Windows NT Memory Model

An excellent example of how the user mode subsystems, executive services, and the HAL all cooperate and work together is memory management (see Figure 13-11). Windows NT provides memory addresses to an application by way of the WIN32 user mode subsystem. When an application requests the subsystem to write data to some of these assigned addresses, the subsystem turns to the executive services for this service. The component within executive services that manages memory (the virtual memory manager) is responsible for coordinating the interface between the user subsystem and the HAL. This executive service presents the request to the HAL, which is responsible for the actual writing of the data to memory and responds to the executive service when finished. The executive service then reports back to the user subsystem, which, in turn, reports back to the application.

Chapter 4 introduced the Windows NT memory model, which is shown in Figure 13-11. In Figure 13-10, you can see that the virtual memory manager is part of the executive services of the kernel mode. This memory manager interfaces with physical memory in RAM and virtual memory on the hard drive (contained in the Pagefile.sys file) by way of the HAL. Each 32-bit application and NTVDM is assigned its own memory address space, which the

virtual memory manager maps onto physical and/or virtual memory. By this method, an application cannot hang the system by storing information in memory that another application or the OS is trying to read, since the application cannot directly access memory.

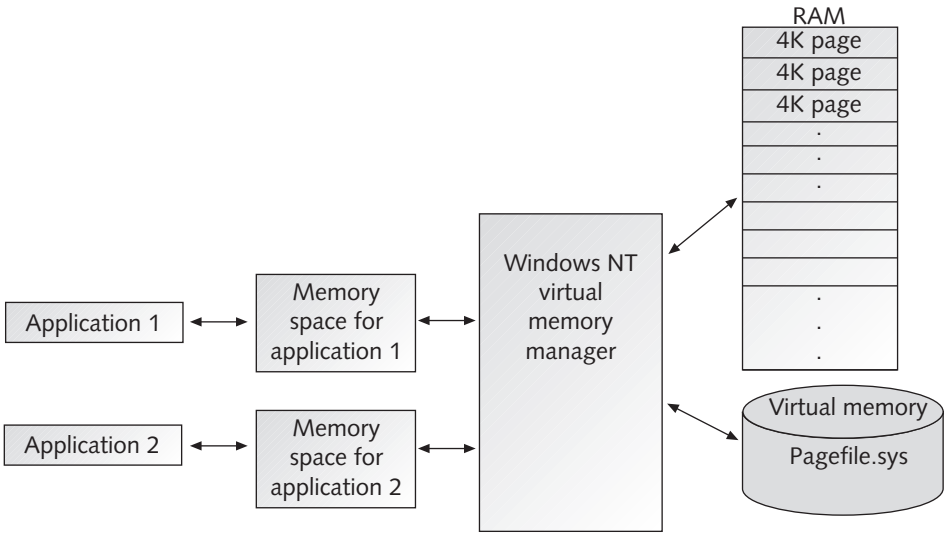

Figure 13-11 Windows NT memory management

The NT virtual memory manager assigns only one set of memory addresses to each virtual machine, even if more than one application is resident. It is then the job of the resident applications to share the memory. For instance, in Figure 13-9, three 16-bit applications share the same virtual DOS machine inside a WOW. Therefore, the virtual memory manager would have all three 16-bit applications in the WOW share what is considered one virtual address space. These 16-bit applications are responsible for managing their memory addresses so that they do not write to each others' memory addresses and cause another application to hang. The 16-bit applications are sharing memory address space so that they can pass information back and forth through these addresses, as when a spreadsheet passes a graph to a word processor. However, if you want a Windows 16-bit application to have full access to all resources in the NTVDM, you can set the application into its own unique NTVDM apart from other 16-bit Windows applications. Doing so isolates the application from other 16-bit applications and means they cannot share information.

Processes and Threads

Windows NT is a multithreaded OS, which allows for powerful programming so that applications can request more than one event from the CPU to be processed at the same time, and, if the system contains more than one CPU, Windows NT can support this true multitasking environment. Understanding processes and threads is important to grasping the full power of Windows NT. Remember from earlier in the book that a program is a file sitting on secondary storage or ROM BIOS that contains a set of instructions to perform one or

more functions. A **process** is a program or group of programs that is running, together with the system resources assigned to it, such as memory addresses, environmental variables, and other resources. Also, more than one process can run for the same program at the same time. For example, in Figure 13-9, each NTVDM and each 32-bit application is a process. Three NTVDM processes are running, even though all three originated from a single NTVDM program stored on the hard drive. The NTVDM process that contains the WOW has at least three (actually more) programs sharing one process. A **thread** is a single task that the process requests from the kernel, such as the task of printing a file. An NTVDM process can only manage one thread at a time. It passes one task to the kernel and must wait for its completion before passing another task. A 32-bit application written for either Windows 9x or Windows NT can pass more than one thread to the kernel at the same time (multithreading). For example, the application might have one thread performing a print job while it continues with another thread to read a file. An application must be specifically written to manage multithreading. If a computer system contains more than one CPU, the kernel mode manages the threads in such a way that one thread is passed to one CPU and another thread is passed to the other CPU, which makes for a true multitasking environment.

Here is an excellent comparison between the potential performance of Windows NT and that of Windows 9x. Compare Figure 13-9 to Figure 12-14 of Chapter 12, where the Windows 9x virtual machine concept is presented. In Windows 9x, all 32-bit and 16-bit applications run in a single virtual machine. With Windows NT, a 32-bit application is not only released from having to share resources with other applications in the Windows 9x virtual machine, but also can use multithreading so that it can make simultaneous requests to the CPU. However, although you can see the potential for more robust performance under Windows NT, the advantage is lost unless the hardware can handle these requests for resources. If the hardware is very limited, the overhead of Windows NT actually slows down performance.

Virtual DOS Machine

Remember that a virtual DOS machine isolates an application from the rest of the system by providing the entire DOS-like environment to the application. Because a common challenge that arises when a system is running Windows NT is having to run 16-bit applications in a Windows NT environment, NTVDMs are explained in more detail below. A Windows NT virtual DOS machine is made up of four main components:

- Ntvdm.exe, which emulates a DOS environment
- Ntio.sys, which performs the same function as IO.SYS in DOS
- Ntdos.sys, which performs the same function as MSDOS.SYS in DOS
- An instruction execution unit, which is only required for RISC-based computers, because DOS applications expect to work on an Intel-based CPU

As you can see from the four components listed above, all the basics of DOS are present in an NTVDM.

In order for a WOW to run within an NTVDM, the following components are also running within this one NTVDM process:

- Wowexec.exe, which emulates the Windows 3.x environment
- Wow32.dll, which emulates the DLL layers of Windows 3.x, which enhance 16-bit applications
- Krnl386.exe, User.exe, and Gdi.exe, which emulate the corresponding three core programs in Windows 3.x

When Windows NT is loaded, a single NTVDM starts, which is then ready to run any 16-bit Windows applications that are loaded. One limitation of a WOW is that there is no communication between a 16-bit application running in the WOW and a 32-bit application or process running outside the WOW. It can be a difficult, if not impossible, chore for these two applications to communicate. (For example, if you are using a 32-bit word processor and have a graph on a spreadsheet that is a 16-bit application, the spreadsheet probably cannot pass the graph to the word processor.) Setting up an NTVDM is covered later in this chapter.

Windows NT Networking

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One of the main reasons Windows NT is chosen as an OS is its strong networking features. Remember that there are two versions of Windows NT: Windows NT Workstation and Windows NT Server. In a general PC environment, a workstation is a desktop PC that both accesses a network and works as a standalone PC. In the most general sense, a server is a computer that contains data, software, and security validation files that are shared simultaneously by workstations on the network. A server on the network is generally not also a workstation. Even though it may have a keyboard and monitor connected to it, these are generally only used by a network administrator to administer and monitor the network; the server is solely dedicated to serving the network.

All the functionality offered by Windows NT Workstation is available with Windows NT Server. The primary difference between the two is that Windows NT Server offers the additional functionality of administering and monitoring the network from this centralized location. However, either OS can be configured to work as one node in a workgroup or as one node on a domain. A **workgroup** is a logical group of computers and users that share resources (Figure 13-12), where the control of administration, resources, and security is distributed throughout the network. A Windows NT **domain** is a group of networked computers that share a centralized directory database of user account information and security for the entire set of computers (Figure 13-13).

When a group of computers is connected to share resources, you can configure these computers as a network using the workgroup model (the network is administered from individual PCs in a workgroup), or use the domain model (the network is administered from a centralized location in the domain). Resources including data, software, and printers can be shared using either model.

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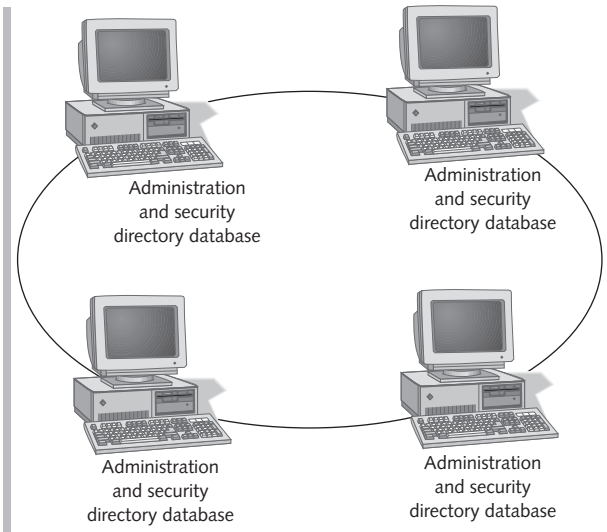

Figure 13-12 A Windows NT workgroup

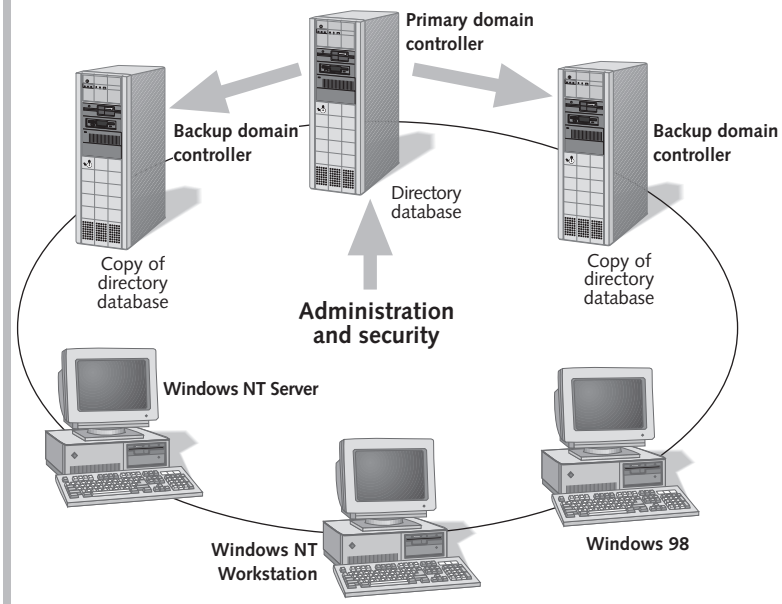

Figure 13-13 A Windows NT domain

Also, as you learn about workgroups and domains, remember that in either case, the group of computers is a logical group, not a geographical group. A workgroup of computers can be in a single building, or it can include PCs in other cities. Distance makes no difference, as

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long as there is networked connectivity either over phone lines or by other means. PCs are grouped together to share resources—for example, a sales staff might need to share a marketing database, and the accounting staff of a company might need to share a journals database. People in both groups are spread over several cities. Members of the sales staff make up the sales workgroup, and members of the accounting staff make up the accounting workgroup, so each user can share resources within the appropriate group.

When you implement Windows NT Workstation, it is often necessary to set users up in a workgroup with other PCs using Windows NT or Windows 9x and to configure the PCs to be members of a domain controlled by a Windows NT server. Understanding the concepts of workgroups and domains and how they are managed is the first step in learning how to support them.

Using Workgroups and Domains

In a workgroup, every computer has its own directory database of user accounts and security policies. Each computer in a workgroup manages the accounts on that computer for other users and computers that want to access information on it. If you are a member of a workgroup and want to allow another user on another PC to access files on your PC, you must establish an account for that user. The information about that account is kept only on your PC.

A workgroup can be made up of computers that use either Windows NT Workstation or Windows NT Server. However, PCs that have Windows NT Server installed must be configured as standalone units. A workgroup does not require a Windows NT server to be present. Workgroups have no centralized account management or security. Workgroups are generally used for a small group of workstations, and the PC support person usually manages each user account on each PC in the workgroup. A domain is used for a large number of workstations, and security for the domain shifts to a business-wide or enterprise function of a network administrator controlling security from a single console.

In a Windows NT domain, a network administrator manages access to the network through a centralized database. In Figure 13-13, you see the possible different components of a Windows NT domain. Every domain has a **primary domain controller** (**PDC**), which stores and controls a database of (1) user accounts, (2) group accounts, and (3) computer accounts. This database is called the directory database or the **security accounts manager** (**SAM**) database.

The directory database can be updated by an administrator logged on to any workstation or server on the domain by accessing the PDC, but the domain can have only one PDC. One or more read-only backup copies of the directory database can be kept on other computers. Each computer with a backup of the directory database is called a **backup domain controller** (**BDC**). A system can be set up so that whenever the database on the PDC is updated, copies are written to each BDC, which is called replication or automated duplication. In Figure 13-13, there are two BDCs, each keeping a copy of the directory database. BDCs use their copy of the SAM database to authenticate users as they log on, thereby relieving the PDC of the burden of authentication functions. This sharing of functions improves performance in domains with many (more than 1000) workstations. Workstations on the domain

are in the lower part of Figure 13-13. A Windows NT network can contain these OSs functioning in these ways: Windows NT Server functioning as a PDC, a BDC, or as a standalone server (a server on the network that has no domain controller functions); Windows NT Workstation functioning as a workstation or as a standalone server, and Windows 9x.

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User Accounts

User accounts are used on PCs to control who has access to what programs, files, and other resources on a PC or network. When using DOS and Windows 9x, the only all-encompassing security is a power-on password, which is a function of the ROM BIOS rather than the OS. Windows NT, however, provides an all-encompassing security feature to the PC. To gain access to a computer, a user must have a **user account** on that computer, which, in a workgroup, must be set up on each computer, or, in a domain, can be set up from the centralized domain server. During the Windows NT installation, an **administrator account** is always created. An administrator has rights and permissions to all computer software and hardware resources.

When Windows NT first boots, someone must log on before the OS can be used. You see the logon screen when you press the **Ctrl+Alt+Del** keys together. (Remember that these keystrokes in the DOS and Windows 9x environment are used to soft boot.) To log on, enter a username and password and click **OK**. Windows NT tracks which user is logged on to the system and grants rights and permissions according to the user's group or to specific permissions granted this user by the administrator.

Administering a Network Besides access to the network, permissions granted to a user and the OS environment that the user has are also controlled by the administrator. An administrator can create user groups and assign restrictions and rights to the entire group that apply to all users. An administrator can also assign individual restrictions and rights to a single user. A **user profile** is a record of information about an authorized user that is used for security and other reasons. It can include the desktop configuration, sound, color, and resources that should be made available to a particular user. The information is kept in a file with a .usr file extension. The administrator can modify a user profile or group profile to control the types of changes a user can make to his or her environment, including the ability to install or configure software or hardware.

In a typical office environment, a single administrator is responsible for maintaining and supporting the hardware and software of many PCs. An administrator usually controls what users can do through user profiles, most commonly giving users just enough rights and permissions to perform their jobs, but not enough to alter hardware or software settings. Thus, users can be denied the ability to set an environmental variable, install a printer, install software, or do any other chores that change the PC software or hardware environment. In many office environments, gone are the days when employees could bring that favorite screensaver or game to work and install it on their PC.

Using Windows NT Server, an administrator can set profiles for an entire network of workstations from his or her PC. The profiles are stored on the server, which can allow users to move from PC to PC with their profiles following them. These users are known to Windows NT as **roaming users**.

Creating a User Account. User accounts are created and managed by the User Manager portion of Windows NT. Follow these directions to set up a new user account.

1. Click **Start**, point to **Programs**, **Administrative Tools**, and then click **User Manager** (see Figure 13-14). The User Manager screen is displayed. The default user accounts, those that NT sets up as part of installation, are an administrator account and one guest account.

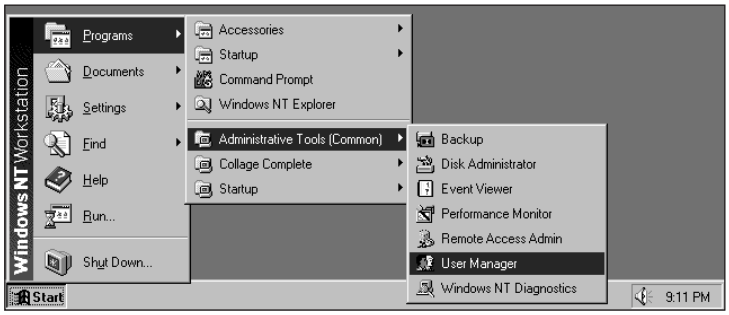

Figure 13-14 The User Manager under Administrative Tools of Windows NT can be used to add a new user

2. To create a new user account, click **User** on the menu bar and then click **New User**. The New User dialog box opens (see Figure 13-15).

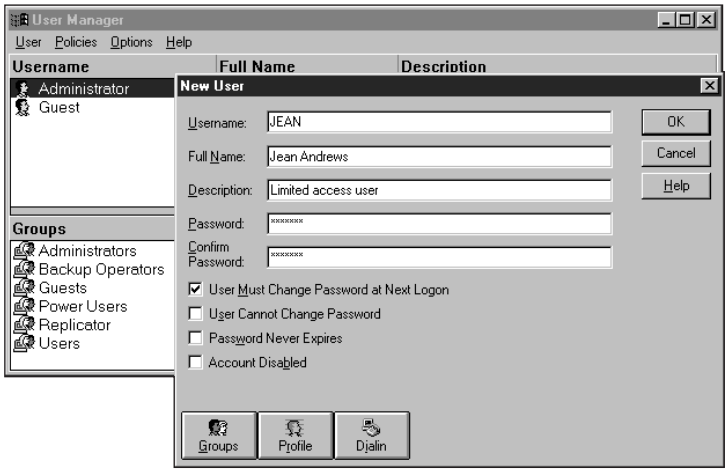

Figure 13-15 Use the New User dialog box to provide information about a user

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3. Enter the information requested about the user. When logging on, the user will enter the username and password. Notice in Figure 13-15 that the option has been selected that requires the user to change his/her password at the next logon.
4. Click the **Groups** button at the bottom of the dialog box to open the Group Memberships dialog box (see Figure 13-16), showing that in this example the new user JEAN is a member of the Users group, the default choice unless the administrator changes it. The available groups that a user is *not* a member of are listed on the right. The group with the most rights is the Administrators group. The administrator can assign rights to an entire group that apply to all users in that group. Click **OK** to return to the New User dialog box.

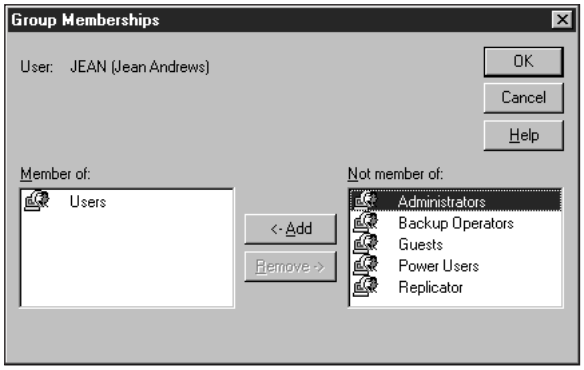

Figure 13-16 Assigning a group membership to a user

5. In the New User dialog box, click the **Dialin** button to open the Dialin Information dialog box (see Figure 13-17).

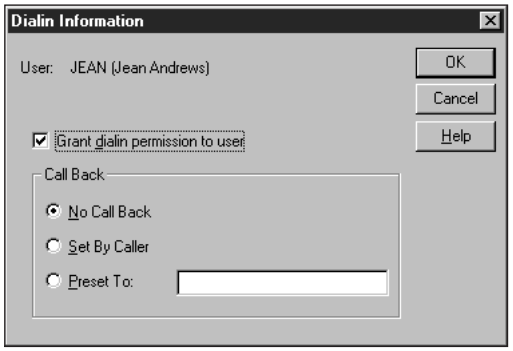

Figure 13-17 Use the Dialin Information dialog box to give a new user permission to dial in to this workstation

6. Check the **Grant dialin permission to user** box to allow the user to access this workstation from a remote PC using a modem.
7. Click **OK** to return to the New User dialog box.
8. In the New User dialog box, click the **Profile** button and enter the path and name of a profile file to apply to this individual user. Then click **OK**.
9. In the New User dialog box, click **OK** to complete the task of adding a new user to the workstation.

To verify that the new account works correctly, log off the system as the administrator and log back on as the new user. To log off, press **Ctrl+Alt+Del**. The Windows NT Security dialog box opens (see Figure 13-18). Click the **Logoff** button. The Windows NT logo screen appears, and no more activity is allowed at this PC until a user logs on. Press **Ctrl+Alt+Del** again to display the logon screen. Enter the new username and password to access the PC under this new user account.

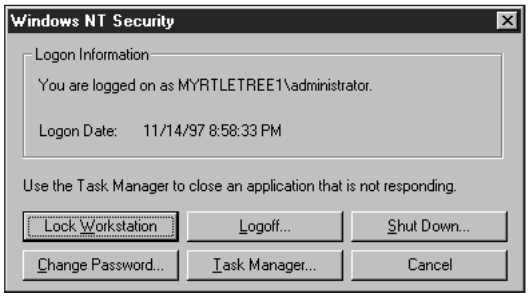

Figure 13-18 Log off the computer using the Windows NT Security dialog box

To demonstrate one way in which Windows NT grants permissions to or withholds permissions from different users, try to establish a new user account different from the JEAN account you just created. From the JEAN account, open the User Manager window again. Click **Start**, point to **Programs**, **Administrative Tools**, and then click **User Manager** to open the window. Click **User** on the menu bar, and then click **New User** (Figure 13-19). Notice that both the New User and Copy options are grayed out on the User menu, because the JEAN account is not allowed to execute these functions. In contrast, the administrator account user menu showed all options in dark type, giving the Administrator access to any of them.

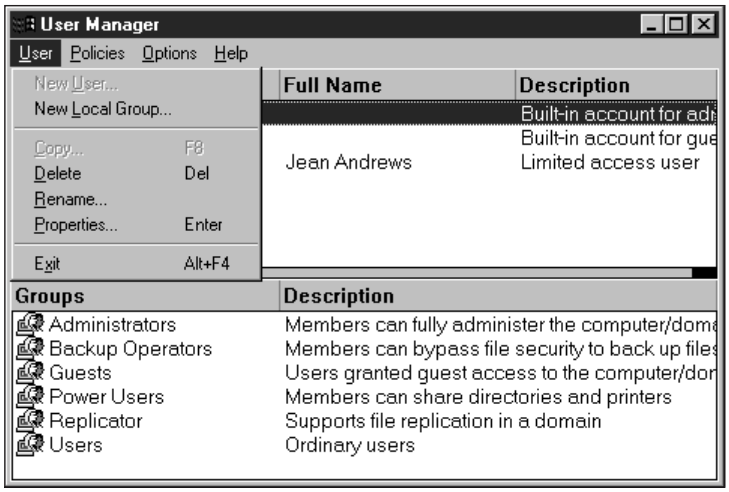

Figure 13-19 Windows NT controls access to options by "graying out" options to users who have not been assigned rights to them

INSTALLING AND CUSTOMIZING WINDOWS NT

This section gives the step-by-step process to install Windows NT. In the following example, we will first examine the system to see if it qualifies for Windows NT and then install the OS.

Preparing for the Installation

Before beginning the installation of Windows NT or upgrading from DOS or Windows 9x to Windows NT, you need to prepare for the installation.

Preparing for Windows NT

To determine if your hardware can support Windows NT, begin by searching the HCL. If a device on your system is not on the HCL, contact the manufacturer for a Windows NT driver. (Remember that if no driver exists, you cannot use the device with Windows NT.) Be sure you have enough hard drive space. Windows NT requires about 120 MB of drive space to install itself, and more if the cluster size is large. A floppy drive and CD-ROM drive are required. For computers without a CD-ROM drive, Windows NT can be installed from a server over a network.

If you are using an Intel-based computer, you can use the **NT Hardware Qualifier (NTHQ)** program found on the Windows NT installation CD-ROM to determine if your system can handle Windows NT. To use Qualifier, boot from a disk onto which you have

copied the program, and the utility will examine your system to determine if all hardware present qualifies for NT. Use the following directions to create and use the NT Hardware Qualifier:

Create the NTHQ bootable disk using any computer that has DOS or Windows 9x installed:

1. Insert a bootable disk in drive A.
2. To have Windows NT create the Hardware Qualifier disk, from a DOS prompt or from the Run dialog box of Windows 9x, enter this command substituting the drive letter of your CD-ROM drive:

   ```
   D:\Support\Hqtool\MakeDisk.bat
   ```

3. Using the computer that you want to install Windows NT, boot from the newly created disk. The following message will be displayed on your screen:

   ```
   Preparing NTHQ
   ```

   You can watch as NT tells you it is creating a RAM drive and copying files to it. Next a screen appears informing you that the report the utility generates will take several minutes and will be written to the disk and saved as Nthq.txt.

4. Print the report.

Figure 13-20 contains a portion of a sample report from the NTHQ. Note that the two devices listed at the top were not found in the NTHQ. To determine if these devices will work with Windows NT, check the latest HCL on the Microsoft Web site or contact the manufacturer of each device.


```
Adapter Description: CIRRUS LOGIN PnP V34 MODEM
Adapter Device ID: CIR1000
Listed in Hardware Compatibility List: Not found-check the latest HCL

Adapter Description: OPL3-SAX Sound Board
Adapter Device ID: YMH0024
Listed in Hardware Compatibility List: Not found-check the latest HCL

Adapter Description: S3 Inc. 801/928/964
Listed in Hardware Compatibility List: Yes

Adapter Description: Adaptec AHA-1522
Listed in Hardware Compatibility List: Yes

Adapter Description: Sound Blaster Adapter or compatibles
Listed in Hardware Compatibility List: Yes

Adapter Description: Joystick/game port
Listed in Hardware Compatibility List: Yes
```

Figure 13-20 Sample report from the NT Hardware Qualifier

Choosing the Right File System

Remember that when you install Windows NT, you must consider a number of criteria before choosing which of the two available file systems you want, FAT16 or NTFS. If you plan to have a dual boot on your PC with either DOS or Windows 9x, use the FAT16 file system. If you need a high level of security, remember that NTFS offers a higher level of security, including security features unavailable with FAT. If Windows NT is the only OS on the hard drive and security is an issue, then use NTFS. RISC-based computers must use FAT for the active partition.

Step-by-Step Installation

Below is a discussion of how to install Windows NT as the only OS on a system, and as the second OS on a system that already has Windows 9x, creating a dual boot.

Installing Windows NT as the Only OS

Windows NT comes with three disks that contain a simplified version of Windows NT, enough to boot a PC. If the hard drive does not contain an OS, the installation begins by booting from these three disks. After Windows NT has loaded these three disks, it can access the CD-ROM drive, and installation continues from the CD. The program on the CD executed at that point is Winnt.exe. A faster version of Winnt.exe on the CD-ROM named Winnt32.exe also can be used instead of Winnt.exe. Winnt32.exe can be run only after Windows NT has already been installed the first time; it is used to upgrade from an older version of NT to a new version or to reinstall a corrupted version.

The three setup disks can later be used to boot the PC if files on the hard drive become corrupted. You can also create a new set of bootable disks. How to do this is discussed later in the chapter.

Follow these steps to install Windows NT:

1. Insert the Windows NT CD in the CD-ROM drive, insert setup disk 1 into the floppy drive, and boot the PC. You will be asked to insert disk 2.
2. You see a "Welcome to Setup" message. You will be asked to insert disk 3. Press **Enter** to continue. Setup lists the mass storage devices it detected. Press **Enter** to continue.
3. The licensing agreement appears. Scroll to the bottom of the document and press **F8** to indicate your agreement and continue.
4. Setup lists hardware and software components it detected. Press **Enter** to continue.
5. Setup lists existing partitions and space available for creating new partitions. For example, if part of the drive has previously been formatted as drive C with 2047 MB of storage and the other part is still unpartitioned, the following information appears:

```
2442 MB Disk 0 at Id 0 on bus 0 on atapi
C: FAT  2047 MB
Unpartitioned space 394 MB
```

Setup is listing the spaces on the hard drive where it can install the OS, and asking you to make the choice. For this example, highlight **Unpartitioned Space** and press **C** to create a new partition.

6. Setup asks you for the size of the partition, creates it, and informs you it will next format the partition, and prompts you to select a file system for the partition. It then lists the following file systems:

   ```
   Format the partition using the FAT file system
   Format the partition using the NTFS file system
   ```

   Select a file system and press **Enter**.

7. After the formatting is completed, Setup asks for this information:

   ```
   Setup installs Windows NT files onto your hard disk.
   Choose the location where you want those files to be
   installed: \WINNT
   ```

   The default choice is to install Windows NT in the \Winnt directory. Accept the default by pressing **Enter**.

8. Setup now asks for permission to examine the hard drive for corruption. You can either allow it by pressing **Enter** or skip this examination by pressing **Esc**.

9. Setup tells you that it is copying files to the hard drive. After the copying is complete, the following message appears:

   ```
   Press ENTER to restart your computer.
   When your computer restarts, Setup will continue.
   ```

10. Up to this point in the installation, all screens appeared to be DOS-like with little graphic user interface and no use of the mouse. When the PC reboots, you are using a true Windows GUI. The opening screen lists the three steps that Windows NT performs to complete the installation:

    ```
    1) Gathering information about your computer
    2) Installing Windows NT networking
    3) Finishing Setup
    ```

    The first item in the list is highlighted. Using the mouse, click **Next** to continue the installation.

11. Setup offers four options:

    ```
    * Typical
    * Portable
    * Compact
    * Custom
    ```

    Select **Typical** and click **Next** to continue.

12. Setup requests a name and the name of your organization. Provide them.

13. You are then asked to enter the CD key that identifies the copy of Windows NT being installed. Provide that.

14. Setup then requests a computer name. You are told that the name must be 15 characters or less and must be unique for your network. This computer name will later be used to identify this computer on a network. Enter the name and click **Next**.

15. Remember that every Windows NT workstation has an administrator account by default. Setup asks for the password for this account:

    ```
    Administrator Account
    Password:
    Confirm Password:
    ```

    Administrators have full privileges on the workstation. Users have fewer privileges, depending on what the administrator assigns them. If other users who will not have administrator privileges will be using this workstation, or if you are concerned about security at this PC, enter a password. If you are the sole user of this PC and security is not an issue, you do not need to enter a password. Just press **Enter**.

16. Setup gives you the option to create an emergency repair disk (ERD, discussed later in the chapter). Select **Yes** to create the emergency repair disk, and then click **Next** to continue.

17. Setup gives you the option to choose what components to install. Since you can later easily install components not installed during the installation, choose **Install the most common components**.

18. Setup returns to the opening Windows NT setup screen (see Step 11) and continues with Installing Windows NT networking.

19. The choices presented are:

    ```
    Do not connect this computer to a network at this time
    This computer will participate on a network, either:
    Wired to the network (ISDN adapter or network adapter)
    Connected remotely to the network using a modem
    ```

    For this example, choose **Do not connect the computer to a network at this time**, and click **Next** to continue.

20. Setup returns to the opening screen (see Step 11). Click **Finish** to finish Setup. You are asked to select the date and time from the Date/Time Properties sheet. Click **Close**.

21. Setup automatically detects the correct display adapter. You can change any options on the Display Properties sheet and then click **OK**.

22. Setup requests that you insert a blank disk labeled emergency repair disk. Insert a blank disk and click **OK**. Setup creates the repair disk.

23. You are instructed to remove the CD and disk from the drives and restart the PC. The installation is done.

Installing Windows NT as the Second OS on the Hard Drive

Installing Windows NT on a hard drive to create a dual boot begins differently, but is otherwise the same as installing Windows NT as the only OS. The Windows NT installation files are stored in the \I386 directory on the CD-ROM drive. If hard drive space is plentiful, you can copy the contents of the \I386 directory and its subdirectories to the hard drive and perform the installation from there, which is faster because access to the hard drive is faster than access to the CD-ROM drive. If the computer is connected to a network, the contents of the \I386 directory can be copied to the network server, and the Winnt.exe program can be executed from the server to install Windows NT on the PC, if certain conditions exist. (Installations from servers are not covered in this chapter.)

Follow these directions to install Windows NT from the CD-ROM drive as a second OS:

1. Insert the Windows NT installation CD in the drive. If the PC auto-detects the CD, you see the Windows NT opening screen. Click **Windows NT Setup**. If the PC does not auto-detect the CD, click **Start**, **Run** and enter this command in the Run dialog box substituting the drive letter of your CD-ROM drive: **D:\I386\Winnt.exe**.
2. A dialog box appears (Figure 13-21) asking for the location of the installation files. For Intel-based computers, choose the **\I386** directory. Confirm the location of the installation files and press **Enter**. If setup can recognize a formatted hard drive, it copies files from the installation source media (in this example, the CD-ROM drive) to the hard drive.

Figure 13-21 The first dialog box of the Windows NT Setup program asking for the location of the installation files

3. Reboot the PC. Then the installation continues as described above beginning with Step 2.

After the installation is complete, when the PC reboots, it detects two OSs, and shows a startup menu (called the **boot loader menu**), giving you the choice between Windows NT Workstation Version 4.0 and Microsoft Windows (Windows 95 or 98). Select **Windows NT Workstation version 4.0**, which then loads.

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Installing a Local or Network Printer

After the Windows NT installation is complete, you can install a printer. Follow these step-by-step directions:

1. Click **Start**, point to **Settings**, and then click **Printers**. The Printers screen opens.
2. Double-click **Add Printer**. The Add Printer Wizard opens, as in Figure 13-22. If this is a local printer operating from the PC's printer port, select **My Computer** and click **Next**.
3. A list of ports is displayed. Select **LPT1**: and click **Next**.
4. A list of manufacturers and printer models is displayed (see Figure 13-23). Select first the manufacturer and then the model from the list. If your printer is not listed, and you have the printer driver for Windows NT on disk or CD-ROM, click **Have Disk**. Drivers designed for Windows 9x might or might not work. If you select a manufacturer and model from the Windows NT list, Windows NT asks for the location of the \I386 directory where driver files are located. Insert the Windows NT CD-ROM and, if necessary, change the path to the files in the dialog box that is displayed.

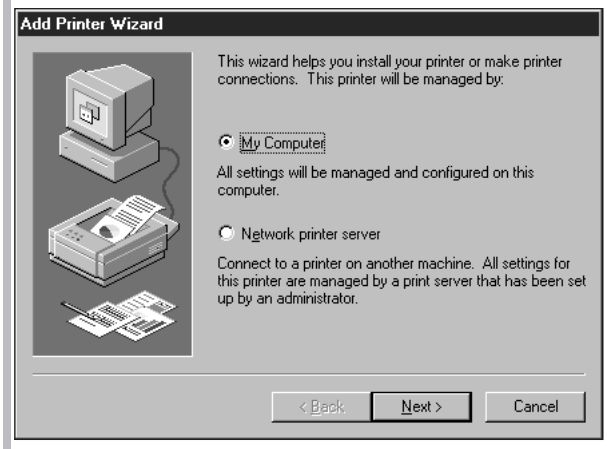

Figure 13-22 The Add Printer Wizard

To eliminate the need to have the CD-ROM readily available for installing a device, you can copy the entire contents of the \I386 directory and its subdirectories from the CD to your hard drive or to a server on your network.

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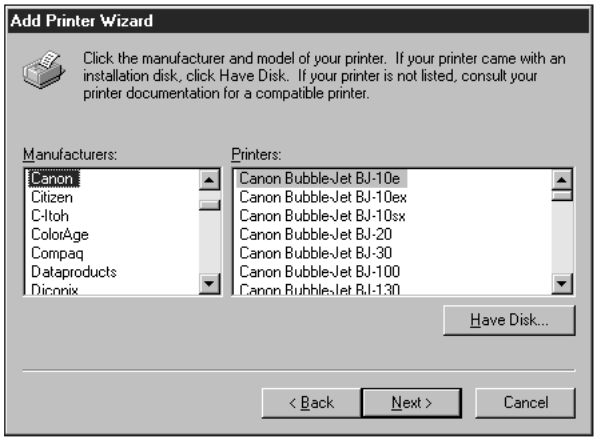

Figure 13-23 Select the manufacturer and model of your printer

5. You are asked for the printer name, which will later appear in the list of available printers. Windows NT provides a default name, but you can select your own. Click **Next** to continue.
6. The Add Printer Wizard asks if this printer will be shared with others on a network. If you click Shared, you must enter a printer name unique to the network and the printer is then made available for others on the network. If the printer is to be shared, you have to tell the system what operating systems are on the network that will use the printer. More than one OS can be selected. If the printer is only to be used by your PC, click **Not Shared** and click **Next** to continue.
7. Print a test page. Select **Yes** to print the test page, and then click **Finish** to complete the installation. Close the Printer window.

13

Supporting Windows NT and Applications

Comprehensive coverage of Windows NT administration is beyond the scope of this book, but this chapter does cover a few common procedures that apply to supporting a standalone NT PC using both 16-bit and 32-bit applications. How the boot process works and how to troubleshoot problems during booting is also covered.

The Windows NT Boot Process

Understanding the boot process and making changes to it are critical when supporting Windows NT. (Also, Windows 2000 uses this same boot process.) When an NT PC is first turned on, the boot load menu asks you to select an OS. You can control this menu from the System Properties dialog box of the Control Panel. Click **Start**, point to **Settings**, and then click **Control Panel**. The Control Panel shown in Figure 13-24 allows you to configure Windows NT, add hardware devices and software, and configure the environment for applications.

Figure 13-24 The Windows NT Control Panel

Double-click the **System** icon. The System Properties box opens. Click the **Startup/Shutdown** tab (see Figure 13-25). From the Startup drop-down list, select the OS that you want to start by default. Select the number of seconds you want the system to wait before it chooses the default option. Also from this tab, you can choose what you want the system to do when an error occurs that prevents Windows NT from loading (called a **fatal system error**). You are given the option to "Write an event to the system log" which can later be viewed under the event viewer. When you make changes and click OK, you are told that the system must reboot before the changes take effect.

If you are having problems booting Windows NT, choose to "Write an event to the system log file" in the System Properties dialog box. Later a Microsoft support person can use this memory dump file to help in diagnosing the boot problem.

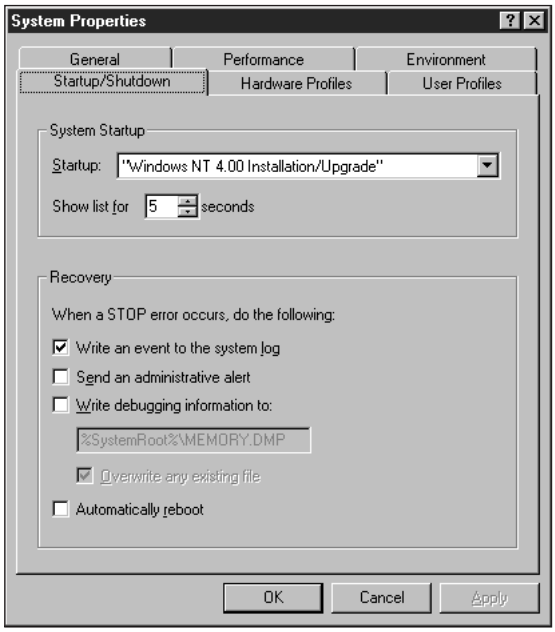

Figure 13-25 System Properties dialog box showing Startup/Shutdown tab

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What Happens During the Boot Sequence

The following is a look behind the scenes with a description of each step in the boot process. As you read, refer to Table 13-2 for an outline of the boot sequence for Intel-based computers.

Table 13-2 Steps in the Intel-based CPU boot process

Description	Step
POST (power-on self test) is executed.	1. Performed by startup BIOS
MBR (Master Boot Record) is loaded, and the master boot program within the MBR is run. (The master program is at the very beginning of the hard drive, as part of the partition table information. The program searches for and loads the OS boot record of the active partition.)	2. Performed by startup BIOS
Boot sector from active partition is loaded, and program in this boot sector is run.	3. Performed by MBR program
Ntldr (NT Loader) file is loaded and run. (The Ntldr file is the initially executed Windows NT OS file and is similar to Io.sys in DOS and Windows 9x.)	4. Performed by boot sector program
Processor is changed from real mode to flat memory mode, in which 32-bit code can be executed.	5. Performed by Windows NT loader

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Table 13-2 Steps in the Intel-based CPU boot process (continued)

Description	Step
Minifile system drivers (described below) are started so files can be read.	6. Performed by Windows NT loader
Read Boot.ini file and build the boot loader menu described in the file. (This menu is discussed later in the chapter.)	7. Performed by Windows NT loader
If user chooses Windows NT, then run Ntdetect.com to detect hardware present; otherwise, run Bootsect.dos.	8. Performed by Windows NT loader
Ntldr reads information from the Registry about device drivers and loads them. Also loads the Hal.dll and Ntoskrml.exe.	9. Performed by Windows NT loader
Ntldr passes control to Ntoskrml.exe; load is complete.	10. Last step performed by the loader

BIOS executes POST. First, Startup BIOS performs POST, which happens just as it would regardless of the OS present. After POST, BIOS turns to the hard drive to load an OS. Remember from earlier chapters that BIOS looks for the partition information at the beginning of the hard drive.

BIOS executes the MBR program. The first thing in the partition information that BIOS needs is the MBR (Master Boot Record) containing the master boot program. Remember from earlier chapters that the master boot program is the very first thing written in the first sector of a hard drive. The master boot program is followed by the partition table itself, and both are stored in the master boot sector. BIOS executes this master boot program, which examines the partition table, looking for the location of the active partition on the drive, and then turns to the first sector of the active partition to find and load the program in the boot sector of that active partition. So far in the boot process, nothing is different between Windows NT and other OSs.

The MBR program executes the OS boot program. Remember that when DOS or Windows 9x boots, the DOS boot sector contains the name of the initial OS load program, Io.sys. When Windows NT is installed, it edits this boot sector of the active partition, instructing it to load the Windows NT program Ntldr at startup, instead of Io.sys. (It does this even when the PC is configured for a dual boot.)

The boot program executes Ntldr. With the execution of Ntldr, Windows NT then starts its boot sequence. This program is responsible for loading Windows NT and performing several chores to complete the load. It then passes off control to the OS.

Ntldr changes the processor mode and loads a file system. Up to this point, the CPU has been processing in real mode; every program had complete access to system resources. Windows NT does not process in real mode. Ntldr is a 32-bit program and begins by changing the CPU mode from real mode to a 32-bit mode called **32-bit flat memory mode**, in order to run its 32-bit code. Next a temporary, simplified file system called the **minifile system** is started so that Ntldr can read files from either a FAT or an NTFS file system.

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Ntldr reads and loads the boot loader menu. Ntldr then is able to read the Boot.ini file, a hidden text file that contains information needed to build the boot loader menu discussed earlier. The menu is displayed, and the user can make a selection or, after the preset time expires, the default selection is used.

Ntldr uses Ntdetect.com. If Ntldr is to load Windows NT as the OS, Ntldr runs the program Ntdetect.com, which checks the hardware devices present and passes the information back to Ntldr. This information will later be used to update the Windows NT registry concerning the last-known good hardware profile used (the registry is discussed later in the chapter).

Ntldr loads the OS and device drivers. Ntldr then loads Ntoskrnl.exe, Hal.dll, and the System hive. The System hive is a portion of the Windows NT registry that includes hardware information that is now used to load the proper device drivers for the hardware present.

Ntldr passes control to Ntoskrnl.exe. Ntldr then passes control to Ntoskrnl.exe, and the boot sequence is complete.

An operating system other than Windows NT is chosen. If a selection was made from the boot loader menu to load an OS other than Windows NT, such as DOS or Windows 9x, Ntldr does not load Ntdetect.com or complete the remaining chores to load Windows NT, but loads and passes control to the program Bootsect.dos, which is responsible for loading the other OS.

When repairing a corrupted hard drive, a support person often copies files from one PC to another. However, the Bootsect.dos file contains information from the partition table for this particular hard drive and cannot be copied from another PC.

The files needed to successfully boot Windows NT are listed in Table 13-3. (In the table, references to *\winnt_root* follow Microsoft documentation conventions and mean the name of the directory where Windows NT is stored, which is \Winnt by default.)

Table 13-3 Files needed to successfully boot Windows NT

File	Location
Ntldr	Root directory of the system partition (usually C:\)
Boot.ini	Root directory of the system partition (usually C:\)
Bootsect.dos	Root directory of the system partition (usually C:\)
Ntdetect.com	Root directory of the system partition (usually C:\)
Ntbootdd.sys*	Root directory of the system partition (usually C:\)
Ntoskrnl.exe	*winnt_root*\system32 directory of the boot partition
Hal.dll	*winnt_root*\system32 directory of the boot partition
System	*winnt_root*\system32\config of the boot partition
Device drivers	*winnt_root*\system32\drivers of the boot partition

*Ntbootdd.sys is only used with a SCSI boot device.

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Troubleshooting the Boot Process

Windows NT offers several tools and methods to aid in troubleshooting and fixing problems that happen during the boot process. For instance, each time the OS boots and the first logon is made with no errors, the OS saves a copy of the hardware configuration from the registry, which is called the Last Known Good configuration. The next time the PC boots, if an error occurs, it can use the Last Known Good configuration. Windows NT also offers a set of boot disks and an emergency rescue disk. If the emergency rescue disk has been kept up to date, it can be invaluable in solving boot problems. This section discusses how to use all three of these tools in troubleshooting the boot process.

Last Known Good Configuration The key in the registry that contains the Last Known Good configuration is:

```
HKEY_LOCAL_MACHINE\HARDWARE
```

You can select the Last Known Good configuration from the Windows NT menu that displays when a problem is encountered during the boot process. For example, if you install a new device driver, restart Windows NT, and find that the system hangs, you can use the Last Known Good configuration to revert back to the previous configuration.

Because the configuration information is not saved to the Last Known Good area until after the logon, if you are having trouble with the boot, don't attempt to log on. Doing so will cause the Last Known Good to be replaced by the current configuration, which might have errors.

For example, if you have installed a new video driver and you restart Windows, but the screen is very difficult to read, don't log on. Instead, press the reset button to reboot the PC. When given the choice, select Last Known Good from the startup menu.

To prevent hard drive corruption, if you are having problems booting Windows NT, wait for all disk activity to stop before pressing the reset button or turning off the PC, especially if you are using the FAT file system.

If you accidentally disable a critical device, Windows NT decides to revert to the Last Known Good for you. You are not provided with a menu choice.

Reverting to the Last Known Good causes the loss of any changes made to the hardware configuration since the Last Known Good was saved. Therefore, it is wise to make one change at a time to the hardware configuration and reboot after each change. That way, if problems during booting are encountered, only the most recent change is lost.

If you are having problems booting in Windows NT, don't log on, because if you do, you will overwrite your previous Last Known Good.

Windows NT Boot Disks With Windows 9x and DOS, any single disk could be formatted as a boot disk or system disk. Windows NT is different. It requires three disks to hold enough of Windows NT to boot. However, formatting a disk to just hold data or software can be done using Explorer.

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When a disk is formatted by Windows NT, the boot sector is written to boot the Ntldr program instead of Io.sys, as DOS and Windows 9x do. To format a disk, use Windows NT Explorer. Right-click the **3½ Floppy (A:)** line in Explorer and choose **Format** from the shortcut menu. Figure 13-26 is displayed.

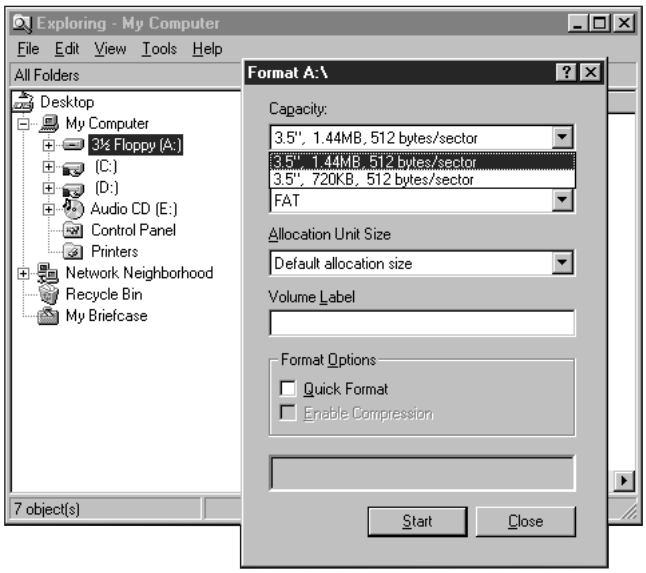

Figure 13-26 Windows NT dialog box used to format a disk

The only file system available for a disk is FAT. Note in the figure that there is no option to make the disk a system disk or boot disk. If you try to boot from a disk that has been formatted by Windows NT, this error message displays:

```
BOOT: Couldn't find NTLDR
Please insert another disk
```

Creating boot disks is done by a different method. Remember that Windows NT comes with a set of three disks that are initially used to boot the machine before the installation continues from the CD-ROM. After the OS is installed, you can use these disks in an emergency to boot the OS. These three disks come with Windows NT, but you can make extra sets. The set of boot disks is the same no matter what PC you are using. The disks contain no special information about your system.

If the original three disks to boot Windows NT become corrupted or are lost, you can make extra copies using Winnt32.exe if you are running Windows NT, or using Winnt.exe if you are running another OS, such as DOS or Windows 9x (explained below). You do not have to be working on the PC where you intend to use the disks in order to make them, since the disks don't contain unique information for a PC. Proceed as follows to create boot disks using Windows NT:

1. Click **Start**, **Run** and enter the path and name of the program with the /OX parameters. These parameters say to only create the set of three disks without

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performing a complete installation. Note the E:\I386\winnt32.exe/ox entry in the Run dialog box of Figure 13-27. This is the command line from within Windows NT used to create the disks when drive E contains the Windows NT installation CD.

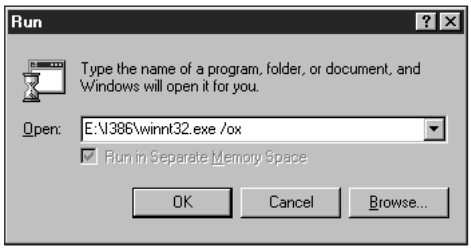

Figure 13-27 Using Winnt32.exe to create a set of boot disks

2. The program asks for the location of the installation files. In this example, enter **E:\I386**. You are then prompted to insert three disks. The program creates the disks beginning with disk 3.

Windows NT does not have a Safe Mode as does Windows 98, so, if the PC later cannot boot Windows NT from the hard drive, these three disks can be used to load Windows NT, which loads using a generic VGA mode. After Windows NT is loaded, use the Emergency Repair Disk to restore critical system files to their state at the time the last update was made to the emergency repair disk.

The Windows NT Emergency Repair Disk A fourth important disk is the Emergency Repair Disk (ERD), which does contain information unique to your OS and hard drive. You are given the opportunity to create the disk during installation. Always create this disk, because it is your record of critical information about your system that can be used to fix a problem with the OS.

The ERD is, in effect, a backup of the Windows NT registry on your hard drive, which contains all the configuration information of Windows NT. In addition, information that is used to build a NTVDM to run DOS applications is also included on the disk. The files on the ERD are listed in Table 13-4. More about each file is covered later in the chapter when the registry is discussed. Files stored on the ERD are also written to the hard drive during the installation process. Using Explorer, you can see the files listed in the *winnt_root*\repair folder.

After the installation, you can create a new ERD or update the current one by using the Rdisk.exe utility in the *winnt_root*\system32 folder. You should update the disk any time you make any major changes to the system configuration. To use the Rdisk.exe utility, click **Start**, **Run**, and then either click **Browse** or enter the path to the utility. Add the /S option so that the utility also updates the SAM, Default, and Security files of the Registry.

If Windows NT is stored on drive D, the command line is:

```
D:\WINNT\System32\rdisk.exe /s
```

A+ OS 3.1

Files are first updated to the *winnt_root*\repair directory, and then you are given the opportunity to create a new ERD.

Using the boot disks and ERD to recover from failed boot. If you cannot recover Windows NT from the Last Known Good hardware profile, the next step is to boot from the set of three boot disks that come with the Windows NT CD-ROM or that you made using either Winnt.exe or Winnt32.exe. The Windows NT programs on these disks may also request that you provide the ERD. Insert the first boot disk and reboot. You will be prompted to insert disk 2, followed by disk 3. The Setup menu in Figure 13-28 is then displayed.

Table 13-4 Files on the Emergency Repair Disk

File	Description
Setup.log	A read-only, hidden system file that is used to verify the files installed on a system
System._	A compressed file containing the HKEY_LOCAL_MACHINE\SYSTEM Registry key
Sam._	A compressed file containing the security accounts manager HKEY_LOCAL_MACHINE\SAM Registry key
Security._	A compressed file containing security information from the HKEY_LOCAL_MACHINE\SECURITY Registry key
Software._	A compressed file containing software information from the HKEY_LOCAL_MACHINE\SOFTWARE Registry key
Default._	A compressed copy of the Default hive of the Registry
Config.nt	The Windows NT version of CONFIG.SYS (\winnt_root\Systems32\Config.nt), used for creating a virtual DOS machine (NTVDM)
Autoexec.nt	The Windows NT version of AUTOEXEC.BAT (\winnt_root\Systems32\Autoexec.nt) used for creating a virtual DOS machine
Ntuser.da_	A compressed copy of \winnt_root\profiles\defaultuser\ntuser.dat

13

```
Windows NT Workstation Setup

Welcome to Setup.
The Setup program for the Microsoft(R) Windows NT(TM) OS version 4.0
prepares Windows NT to run on your computer.

       *To learn more about Windows NT Setup before continuing, press F1
       *To set up Windows NT now, press ENTER
       *To repair a damaged Windows NT version 4.0 installation, press R
       *To quit Setup without installing Windows NT, press F3
```

Figure 13-28 Windows NT Workstation Setup menu

Select the option to repair a damaged installation by pressing **R**. When you press R, the following list of optional tasks is displayed:

```
(X) Inspect registry files
(X) Inspect startup environment
```

A+ OS 3.1

```
(X) Verify Windows NT system files
(X) Inspect boot sector
Continue (perform selected tasks)
```

Table 13-5 summarizes the purpose of each task on the Repair menu.

Table 13-5 The purpose of each task on the repair menu

Repair Menu Option	Description
Inspect registry files	This task prompts you before you replace each registry file stored on the ERD. Any changes to security and SAM are lost, and they revert to the state they were in at system installation. Changes to software and system are restored to the last update made to the ERD.
Inspect startup environment	Inspects the Boot.ini file and edits it so that Windows NT is added as an option if it is not already present
Verify Windows NT system files	Identifies and offers to replace files that have been altered from the original files on the Windows NT CD-ROM. Includes verifying files needed to boot.
Inspect boot sector	Verifies that the boot sector on the active partition has the reference to Ntldr and puts it there if needed. This action can correct the problem caused by someone using the DOS SYS command that changes the boot sector to reference a DOS file instead of Ntldr.

By default, all optional tasks listed above are selected. You can choose not to perform a task by highlighting it and pressing **Enter**, which removes the selection mark, X. After you have selected your options, highlight **Continue** and press **Enter**.

Files are copied from the boot disks, as needed, to repair the startup environment. Some of the options listed above use the ERD. You are asked if you have the disk; if you answer positively, you will be asked to insert the disk. For example, boot sector information used to perform the task "Inspect boot sector" is included in the files on the ERD. Setup asks for the disk and restores the boot sector from the information on the disk.

Table 13-6 lists some error messages that might display during the boot process when critical files are missing or corrupted. In all cases listed in the table, the solution is to boot from the boot disks and provide the CD-ROM or ERD when requested by the setup program.

Table 13-6 Some Windows NT errors at startup

Error Message	Missing or Corrupted File
BOOT: Couldn't find NTLDR. Please insert another disk.	Ntldr
NTDETECT V1.0 Checking Hardware … NTDETECT failed	Ntdetect.com
Windows NT could not start because the following file is missing or corrupt: \winnt_root\system32\ntoskrnl.exe. Please re-install a copy of the above file	Ntoskrnl.exe
I/O Error accessing boot sector file multi(0) disk (0) rdisk (0) partition (1):\bootsect.dos	Bootsect.dos

Managing Legacy Software in the Windows NT Environment

Even though it would be convenient if all software running under Windows NT were written in the newer 32-bit code used by Windows 9x and Windows NT, this doesn't always happen. As explained in the discussion above, Windows NT makes provisions for running DOS applications by creating a separate NTVDM for each application, so that each program can run in its native environment. Windows 16-bit applications can run in individual NTVDMs, or several 16-bit Windows applications can run in the same NTVDM so they can share resources. How to do this is discussed next.

Customizing an NTVDM for a DOS Application

To prepare to run a DOS application with Windows NT, first create a shortcut to the DOS application. For example, a quick and easy way to place a shortcut on the desktop is to use Explorer. From Explorer, click the name of the executable file and drag it to the desktop. A shortcut is immediately created. You can edit the name of the shortcut on the desktop by clicking inside the name area, which creates an insertion point in the text.

Next edit the properties of the shortcut. Right-click the shortcut icon. You see a shortcut menu, as in Figure 13-29. Select **Properties** from the menu. In the Properties dialog box, click the **Program** tab. Click **Windows NT** to open the Windows NT PIF Settings dialog box (see Figure 13-30). Notice the .nt file extension on the Autoexec and Config files in the *\winnt_root*\system32 folder. From this dialog box, you can edit the names and locations of these files. Click **OK** to return to the DOS Properties sheet.

Figure 13-29 Right-click a shortcut icon to see the icon's shortcut menu

Each DOS application can have individual initialization files, but by default, they all use these two, AUTOEXEC.NT and CONFIG.NT. You can edit the contents of these two files and put any DOS command compatible with DOS 5.0 in them. These commands will be executed when the NTVDM is first loaded.

To configure memory for a DOS application to run under Windows NT, click the **Memory** tab (see Figure 13-31). In most cases, you should leave the conventional memory at Auto to allow Windows NT to make the selection.

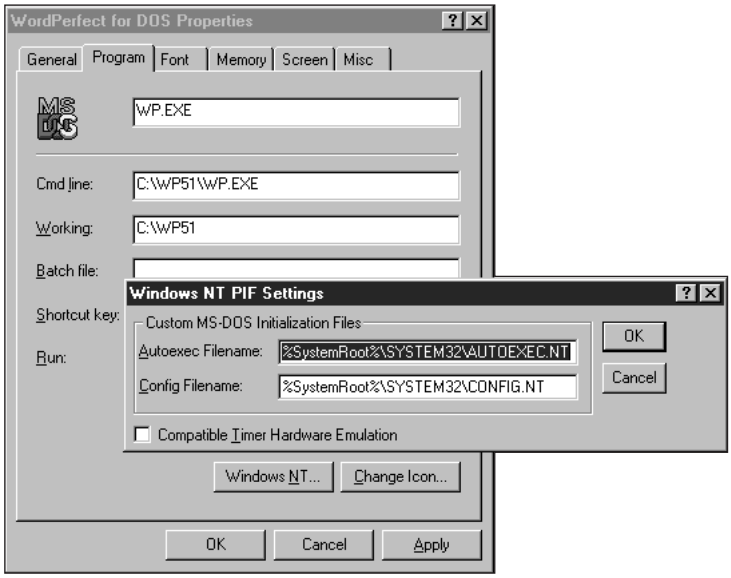

Figure 13-30 Setting the location of initialization files for a DOS application

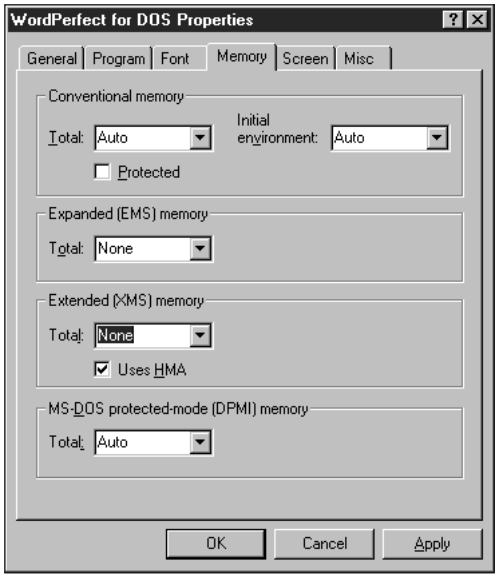

Figure 13-31 The Memory tab of the DOS Properties dialog box

Customizing an NTVDM for 16-bit Windows Applications

As with customizing Windows NT for DOS applications, the first step in customizing Windows NT for 16-bit Windows applications is to create a shortcut for the application. Then you can right-click the **shortcut** and choose **Properties** from the menu. You see the

Windows Properties dialog box. Select the **Shortcut** tab (see Figure 13-32). To run the application in its own individual NTVDM, check **Run in Separate Memory Space**. If you are running a 16-bit application from the Start menu, as in Figure 13-33, when Windows NT recognizes the application to be a 16-bit Windows application, it makes the check box available so that you can choose to run the application in its own memory address space. The box is grayed out if the application is a 32-bit or DOS application.

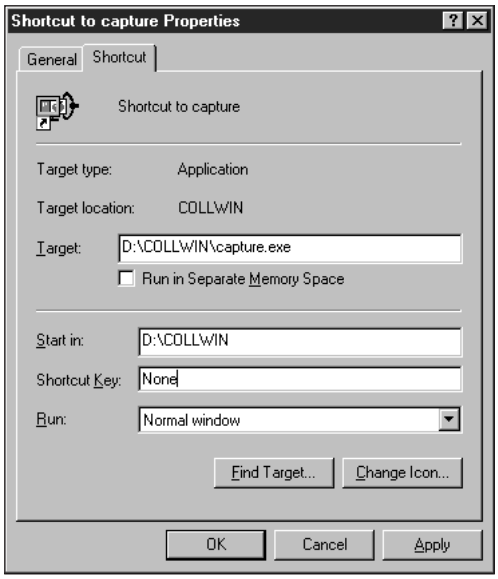

Figure 13-32 Properties dialog box for a 16-bit Windows application

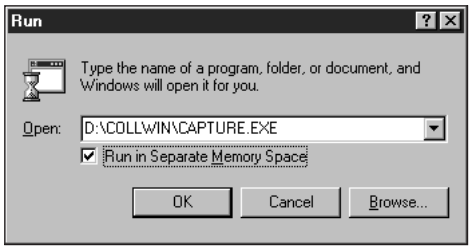

Figure 13-33 Windows NT allows a 16-bit application to run in a separate memory space

Why Applications Might Not Work with Windows NT

The following is a list of reasons that applications might not work with Windows NT:

- DOS applications that try to access hardware directly are shut down by Windows NT.
- A 16-bit Windows application that uses virtual device drivers (VxD) will fail because the virtual device drivers attempt to access hardware directly.

- A 32-bit application that was developed on a different hardware platform than the current PC might not run under Windows NT.
- Some OS/2 applications are not compatible with Windows NT.

THE WINDOWS NT REGISTRY

The **Windows NT Registry** is a hierarchical database containing all the hardware, software, device drivers, network protocols, and user configuration information needed by the OS and applications. Many components depend on the registry for information about hardware, software, users, security, and much more. The Windows NT Registry provides a secure and stable location for configuration information about these entities. Table 13-7 lists ways in which some components use the registry.

The registry is a hierarchical database that follows an upside-down tree structure similar to that used by folders and subfolders. In the next section, you will look at how the registry is organized, how to view the contents of the registry, how to back up and recover the registry, and how Windows NT makes changes to the registry.

How the Registry is Organized

When studying how the registry is organized, keep in mind that there are two ways to look at this organization, the physical organization and the logical organization.

Table 13-7 Components that use the Windows NT Registry

Component	Description
Setup programs for devices and applications	Setup programs can record configuration information in the Registry and query the Registry for information needed to install drivers and applications.
User profiles that are maintained and used by the OS	Windows NT maintains a profile for each user that determines the user's environment. User profiles are kept in files, but, when a user logs on, the profile information is written to the Registry, where changes are recorded, and then later written back to the user profile file. The OS uses this profile to control user settings and other configuration information specific to this user.
When Ntldr is loading the OS	During the boot process, Ntdetect.com surveys present hardware devices and records that information in the Registry. Ntldr loads and initializes device drivers using information from the Registry, including the order in which to load them.
Device drivers	Device drivers both read and write configuration information from and to the Registry each time they load. The drivers read hardware configuration information from and to the Registry to determine the proper way to load.

Table 13-7 Components that use the Windows NT Registry (continued)

Component	Description
Hardware profiles	Windows NT can maintain more than one set of hardware configuration information (called a **hardware profile**) for one PC. The data is kept in the Registry. An example of a PC that has more than one hardware profile is a PC that is also a docking station. Two hardware profiles describe the PC, one docked and the other undocked. This information is kept in the Registry.
Application programs	Many application programs read the Registry for information about the location of files the program uses and various other parameters that are stored in .ini files under Windows 3.x and Windows 9x.

Logical Organization of the Registry

Logically, the organization of the Registry looks like a tree with five branches, called keys or subtrees (see Figure 13-34), which are categories of information stored in the registry. Each key is made up of several subkeys that may also have subkeys under them. Subkeys lead to values. Each value has a name and data assigned to it. Data in the registry is always stored in values, the lowest level of the tree.

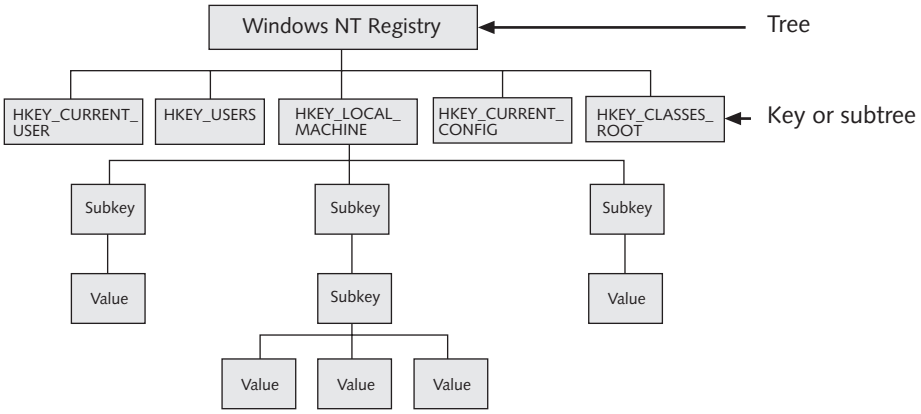

Figure 13-34 The Windows NT Registry is logically organized in an upside-down tree structure of keys, subkeys, and values

Figure 13-35 shows the Windows NT Registry Editor, the window you see when you first open the editor: the subtree level has five cascading windows, one for each subtree. The first window in the figure shows the HKEY_CURRENT_USER subtree and a list of the subkeys in this subtree. Notice in the figure that some subkeys have plus (+) signs in the icon. A + sign indicates that this subkey has subkeys under it. Later in the chapter you will see how to move down these subkeys to the lowest level of the tree, where the values are stored.

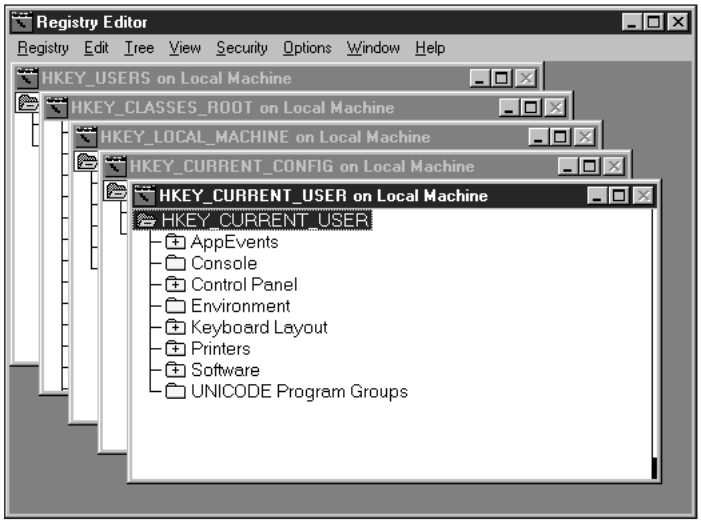

Figure 13-35 The five subtrees of the Windows NT Registry

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Physical Organization of the Registry

The physical organization of the registry is quite different from the logical organization. Physically, the registry is stored in five files called **hives**. There is not a one-to-one relationship between the subtrees and these five files, even though there are five of each. Figure 13-36 shows the way the subtrees are stored in hives, summarized as follows:

- HKEY_LOCAL_MACHINE consists of four hives, the SAM hive, the Security hive, the Software hive, and the System hive.
- HKEY_CURRENT_CONFIG data is kept in portions of two hives, the Software hive and the System hive.
- HKEY_CLASSES_ROOT data is kept in a portion of the Software hive.
- HKEY_USERS data is kept in the Default hive.
- HKEY_CURRENT_USER data is kept in a portion of the Default hive.

From Figure 13-36, you can also see that physically, some subtrees use data that is contained in other subtrees. For instance, the HKEY_CURRENT_USER data is a subset of the data in the HKEY_USERS subtree. HKEY_CURRENT_CONFIG and HKEY_CLASSES_ROOT subtrees use data that is contained in the HKEY_LOCAL_MACHINE subtree. However, don't let this physical relationship cloud your view of the logical relationship among these subtrees. Even though data is shared among the different subtrees, logically speaking, none of the five subtrees is considered subordinate to any other.

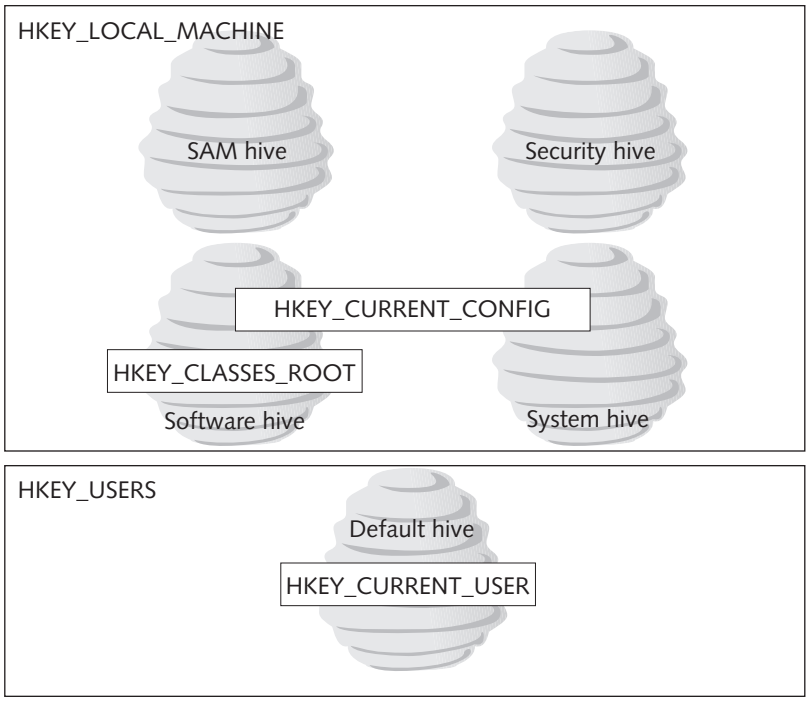

Figure 13-36 The relationship between Registry subtrees (keys) and hives

The Registry hives are stored in the *winnt_root*\system32\config folder as a group of files (see Figure 13-37). In a physical sense, each hive is a file. Each hive is backed up with a log file and a backup file, which are stored in the *winnt_root*\system32\config folder.

In addition, registry information about each user who has ever logged on to this workstation is permanently stored in a file named Ntuser.dat located in the *winnt_root*\profiles folder. The ..\profiles subfolder has the same name as the username. For example, for the username JEAN, the path and name to the file is:

```
C:\WINNT\Profiles\JEAN\Ntuser.dat
```

The information in this file is the same as that temporarily kept in the HKEY_CURRENT_USER subtree while the user is logged on.

A Closer Look at Subkeys and Values

Now let's go back to the logical organization of the registry. The five subtrees of the registry, displayed in Figure 13-35, are listed in Table 13-8 together with their primary functions. As you can notice from the table, the HKEY_LOCAL_MACHINE subtree is the supporting mainstay key of the registry.

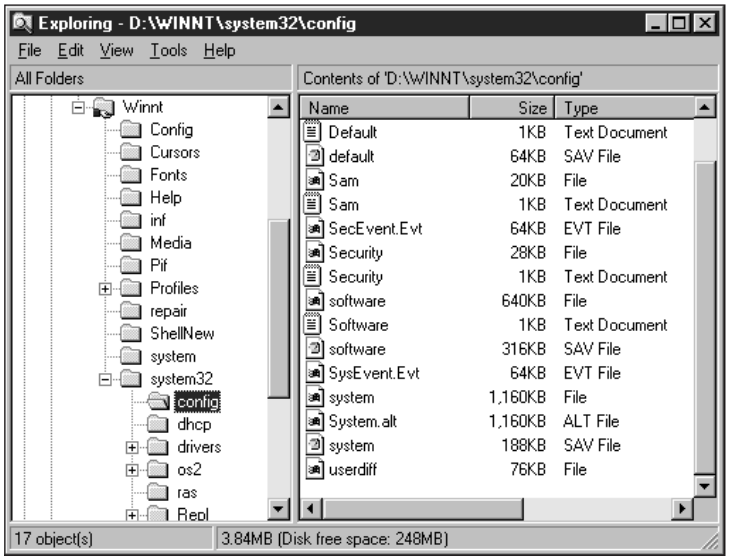

Figure 13-37 The registry is stored in the *winnt_root*\system32\config folder

Table 13-8 The five subtrees of the Windows NT Registry

Subtree (Main Keys)	Primary Function
HKEY_CURRENT_USER	Contains information about the currently logged-on user. Similar information about each user who has ever logged on to this workstation is also kept in a file called Ntuser.dat in a folder with the same name as the username.
HKEY_CLASSES_ROOT	Contains information about software and the way software is configured. This key points to data stored in HKEY_LOCAL_MACHINE.
HKEY_CURRENT_CONFIG	Contains information about the active hardware configuration, which is extracted from the data stored in the HKEY_LOCAL_MACHINE subkeys called SOFTWARE and SYSTEM.
HKEY_USERS	Contains only two subkeys: information used to build the logon screen and the ID of the currently logged-on user.
HKEY_LOCAL_MACHINE	This key contains all configuration data about the computer, including information about device drivers and devices used at startup. The information in this key does not change when different users are logged on.

A+ OS 1.1, 3.2

Windows NT offers two Registry Editors, each with a slightly different look and feel, although they both accomplish the same thing. They are:

- Regedt32.exe located in the *winnt_root*\system32 folder, which shows each key in a separate window (recommended by Microsoft)

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- Regedit.exe located in the *\winnt_root* folder, which shows all keys in the same window and has a look and feel similar to Explorer

In the example below, we use Regedt32.exe to view the Registry to get a close look at registry values. Even though the Registry Editors allow you to make changes to the registry, this should only be done as a last resort, and usually only when you are instructed to do so by a network administrator or Microsoft technical support. *Never* make changes to the Registry without first creating a current ERD.

Figure 13-38 shows a view of the registry using Regedt32.exe all the way down to the value level. Double-click the filename in Explorer or use this command from the Start, Run dialog box to access the Registry Editor.

```
\winnt_root\System32\regedt32.exe
```

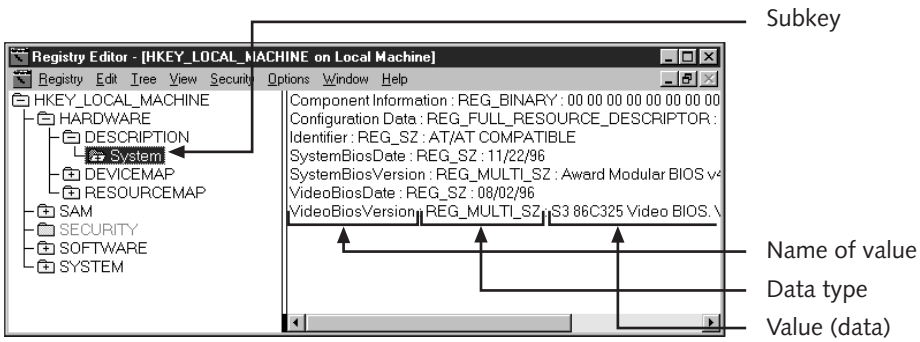

Figure 13-38 Registry Editor showing subkeys and values

13

When you don't plan to make changes to the registry, set the editor to read-only mode to avoid making changes unintentionally. For example, follow these directions to view the HKEY_LOCAL_MACHINE portion of the registry as read-only.

1. Select the **Options** menu and check **Read Only Mode** to avoid making changes unintentionally.
2. Reduce to icons all subtree windows except HKEY_LOCAL_MACHINE.
3. Maximize the HKEY_LOCAL_MACHINE window. The HKEY_LOCAL_MACHINE key has five subkeys. The hardware subkey is the only one that does not relate to a hive. This key is built each time Windows NT is loaded, from information gathered during the boot. (As you work with the Registry Editor, double-click a yellow folder on the left side of the screen to expand the folder, and double-click it again to reduce it.)
4. Double-click **Hardware**, then **Description**, then **System**. Figure 13-38 shows the results of this action; you can now see values within the system subkey on the right side of the Registry Editor screen. Each entry of a value includes a name, a data type, and the value itself, which is sometimes called the **configuration parameter**. The value name is listed first, followed by the data type of the value, followed by the value itself.

5. If you need to edit a value, you can do so by double-clicking the value to open the edit box. You can make changes and click **OK** to record the changes. Because you are in read-only mode, if you double-click a value now, a warning will be displayed saying that your changes will not be saved.
6. Exit the editor by clicking on the **Registry** menu and choosing **Exit**.

Backing Up the Registry

Before editing the registry directly using Regedt32.exe or changing it by installing hardware or software, make a backup of the registry. To back up the registry, use Rdisk.exe (discussed earlier in the chapter) to create an ERD, which also makes a copy of the Registry files to the *winnt_root*\repair folder. After you have confirmed that your changes to the registry are functioning correctly, once again make a new ERD so that your registry backup is up to date.

Installing Software and Hardware

Hardware and software are installed using the Windows NT Control Panel, which looks like, and works in a similar way to, that of Windows 9x (see Figure 13-24). As both are done, changes are made to the Registry. We next look at examples of each.

Installing Software

Software is installed from the Control Panel using the Add/Remove Programs icon. Installation works very much the same way as under Windows 9x. Access the Control Panel by clicking **Start**, pointing to **Settings**, and clicking **Control Panel**. From the Control Panel, double-click the **Add/Remove Programs** icon. The Add/Remove Programs Properties dialog box opens. Any software that installs with a Setup.exe or Install.exe program can be installed using this dialog box. Click **Install**, and the dialog box requests the location of the setup program.

To add new components to Windows NT that were not installed when Windows NT was originally installed, click the **Windows NT Setup** tab of the Add/Remove Programs Properties dialog box. You see a list of all of the Windows NT components. From this list, you can select to install new components or to uninstall components that are already installed.

Installing Hardware Devices

Windows NT builds its list of available hardware devices each time it is booted. This list is not permanently kept in the registry. However, when a new hardware device is installed, device driver information is kept in the registry. New hardware devices are installed from the Control Panel. The steps below describe the installation of a sound card, because this installation is typical of many hardware devices.

1. To install a sound card, access the **Control Panel** and double-click the **Multimedia** icon. The Multimedia Properties dialog box is displayed.
2. Click the **Devices** tab to see a list of multimedia devices.

3. Select **Audio Devices** and click the **Add** button. The Add dialog box opens. You can either select a device driver from the list or click **Unlisted or Updated Driver** to install your own device driver from disk or CD-ROM.

4. If you choose to install your own driver, click **Unlisted or Updated Driver** and click **OK**. The Install Driver dialog box is displayed, asking for the location of the driver. As the example shown in Figure 13-39 shows, the vendor-provided driver is selected. Several versions of the driver (for each of the OSs supported) are located in directories on the CD-ROM that comes with the sound card.

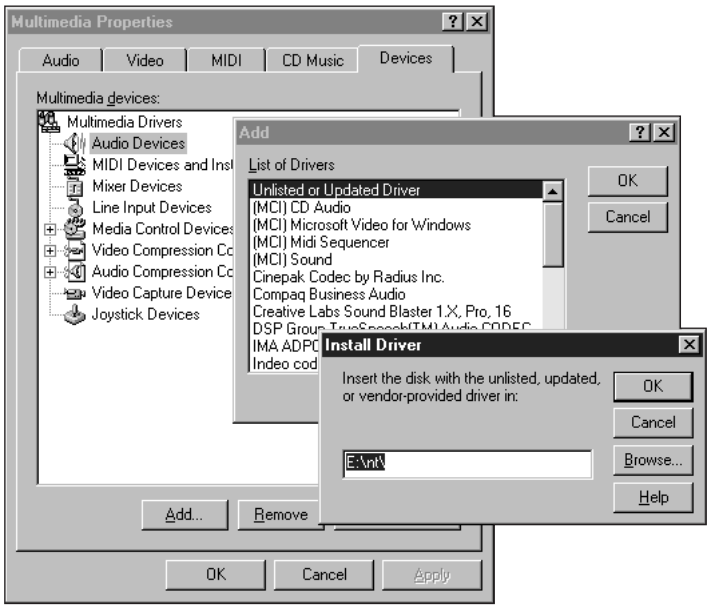

Figure 13-39 When installing a device driver, you can use a driver provided by Windows NT or one from the device vendor

5. In the example CD, the location for the driver is E:\nt\. Enter the path and click **OK** to continue the installation. If Windows NT already has the driver you are installing, the OS gives you the choice to use the driver provided by the vendor or the Windows NT driver.

6. The driver is copied to the hard drive, and then the hardware setup dialog box is displayed, as seen in Figure 13-40. The suggested I/O address, IRQ, and DMA channel are selected, but you can change these values if you are aware of a conflict. Otherwise, leave the values as suggested and click **OK** to complete the installation.

7. The Windows NT Registry is then updated, and you are asked to restart the PC so the changes to the registry can take effect.

8. Install the CD Player component of Windows NT to use the new sound card. As with many devices, software is necessary to use the sound card. The next step is to double-click the Add/Remove Programs icon of the Control Panel and install

the CD Player component of Windows NT in order to use the sound card to play audio CDs. This installation window works just as with Windows 9x.

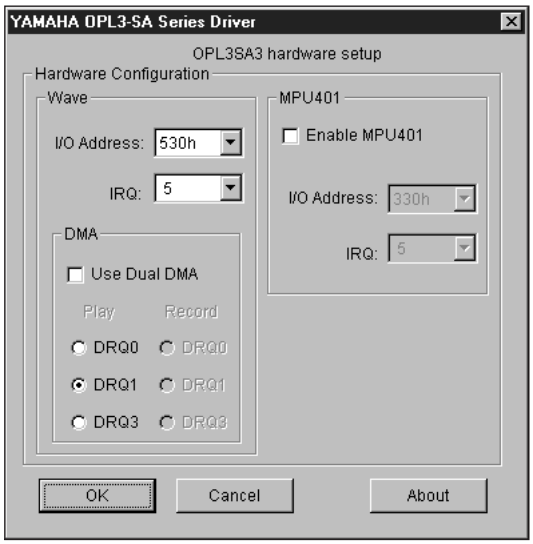

Figure 13-40 Windows NT suggests a hardware setup for the new device

This example is typical of many hardware installations. The Control Panel was used to install the device driver, and you saw how Windows NT suggests the hardware setup resources to use. Next time the PC boots, the registry communicates to the Ntldr program to load the sound card device driver. As the driver loads, it looks to the registry for the list of resources that it will use.

The software to use the CD player is also installed from the Control Panel. This information is now kept in the registry to be used each time the OS loads. The OS uses this registry information to provide the CD Player option under Start, Accessories, Multimedia.

Windows NT Diagnostic Tools

Windows NT provides several diagnostic tools to help support users, the OS, and applications, and to help with troubleshooting. Three tools are discussed below: the Task Manager, the Event Viewer, and Windows NT Diagnostics.

The Task Manager

The Task Manager is a tool that was first introduced with Windows NT 4.0 and is included with Windows 98 and Windows 2000. It allows you to monitor processes and applications running on the PC, and to start and stop them. It also displays performance measurements, including processor time, main memory and virtual memory size, and number of threads, to help in diagnosing problems with poor performance. There are three ways to access Task Manager:

right-click the taskbar and select Task Manager from the shortcut menu, press CTRL, ALT and DEL and select Task Manager from the Security window, or press CTRL, SHIFT and ESCAPE. Either way, the utility Taskman.exe is executed. Click the **Applications** tab to display a list of applications currently running. For instance, in Figure 13-41, three applications are running. This window is actively monitoring all tasks as they are started and stopped by other means than the Task Manager. However, you can end a task, switch from one task to another, and start a new task from this tab as well.

Figure 13-41 The Task Manager lists applications currently running

Click the **Processes** tab to see a list of current processes (see Figure 13-42). In the figure, two programs are subordinate to the Ntvdm.exe process, which provides a NTVDM. Capture.exe is a 16-bit, Windows 3.x application that requires a WOW to run in an NTVDM. Wowexec.exe provides the WOW.

From this tab, you can monitor CPU time and memory used by processes, end processes by clicking on End Process, and see, in a visual format, how some programs are related to others within a process.

Click the **Performance** tab to see a graphical representation of how system resources are being used. CPU usage and memory usage are graphed, and other statistics are displayed at the bottom of the sheet. In Figure 13-43, the sudden jump in CPU usage shown in the graph was caused when a print job with graphics (this screen capture) was sent to the printer. Use the Task Manager to end applications that have locked up, to monitor processes and applications that are draining computer resources, and to search for potential problems with memory and the CPU.

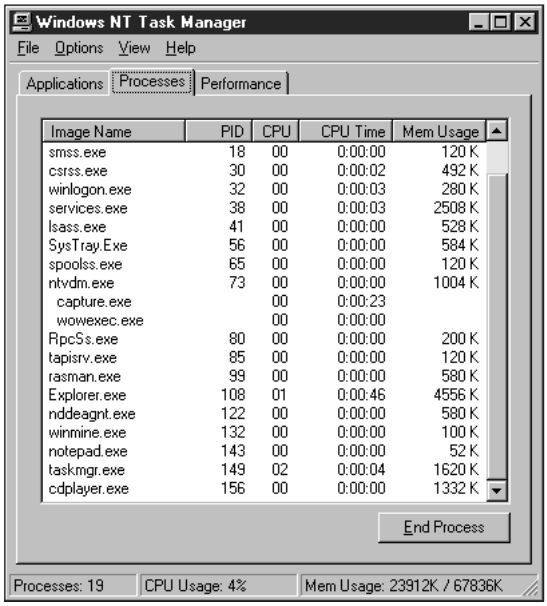

Figure 13-42 The Task Manager tracks current processes and how they are using system resources

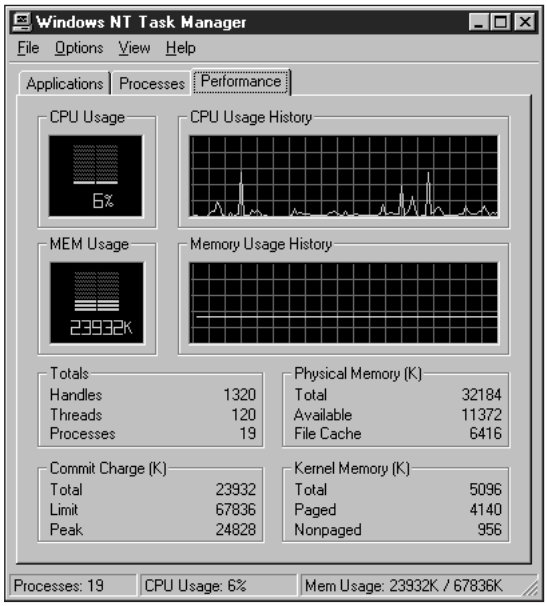

Figure 13-43 The Task Manager monitors system performance

Another diagnostic tool in the Administrative Tools group that measures component and application performance is Performance Monitor. It can track percent processor time indicating how busy the CPU is, interrupts/second indicating performance of hardware devices, and processor queue length indicating CPU performance.

The Event Viewer

A+ OS 3.1

One of the most important uses of the Event Viewer is to view a log that Windows NT created because of a failed event. Most information can be found here to help resolve the failed event. Access the Event Viewer by clicking **Start**, pointing to **Programs**, **Administrative Tools**, and clicking **Event Viewer** in the menu list. The Event Viewer tracks events as they are performed by the applications, the OS, services, or processes, and by user actions. When an attempted action causes a problem, this event, as well as significant successful events, is recorded in the Event Viewer. In Figure 13-44, a failed event is indicated by a stop sign in front of the event line; the eighth event in the log failed. Near the bottom of the list, a possible future problem with an event is indicated by an exclamation point. Events are marked with the letter "i" to indicate that the event completed successfully. To see the details of an event, double-click the event line in the log. For example, to see a description of the problem for the event that failed, double-click that line. The details for the failed event of Figure 13-44 are shown in Figure 13-45. Using the log Menu in the Event viewer window, you can save the log to a log file, open a previously-saved log file, and clear all events from the current log. (Windows 2000 uses the action menu for these same functions.).

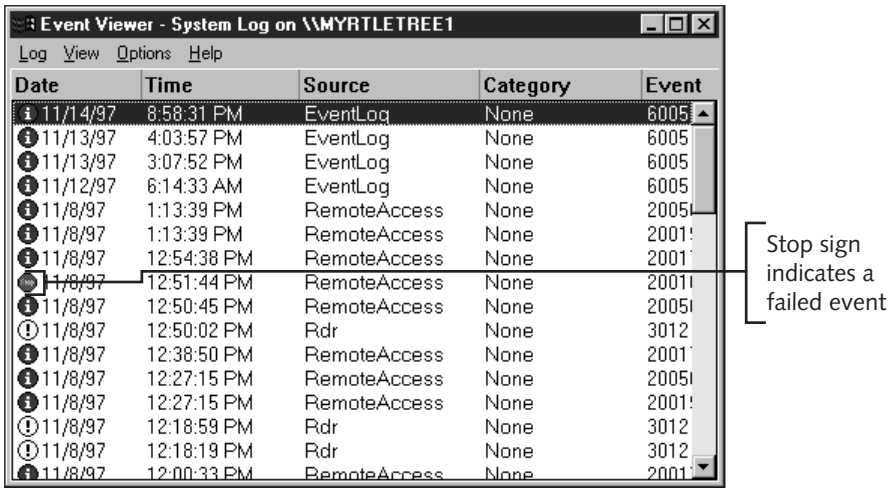

Figure 13-44 The Event Viewer tracks failed events and many successful ones

13

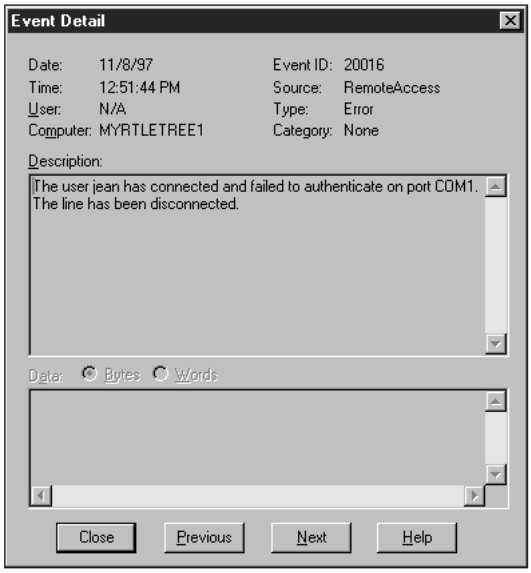

Figure 13-45 The details of a failed event

Windows NT Diagnostic

The Windows NT Diagnostic utility is a graphical view of the Windows NT Registry showing hardware and OS data, which can be used to resolve conflicts, diagnose failed hardware, view information about drivers and services that are loaded, and much more. The utility is located in the Administrative Tools group. Click on **Start**, point to **Programs**, **Administrative Tools**, and click **Windows NT Diagnostics**. Information cannot be updated using this utility, but it is a convenient way to view the information. For example, click the **Resources** tab to see a list of different resources. By using the buttons at the bottom of this sheet, you can see a list of IRQs (see Figure 13-46), I/O ports, DMA channels, memory, and devices in use. Browsing through the Windows NT Diagnostic tabs allows you to see a thorough overview of the hardware and OS configurations.

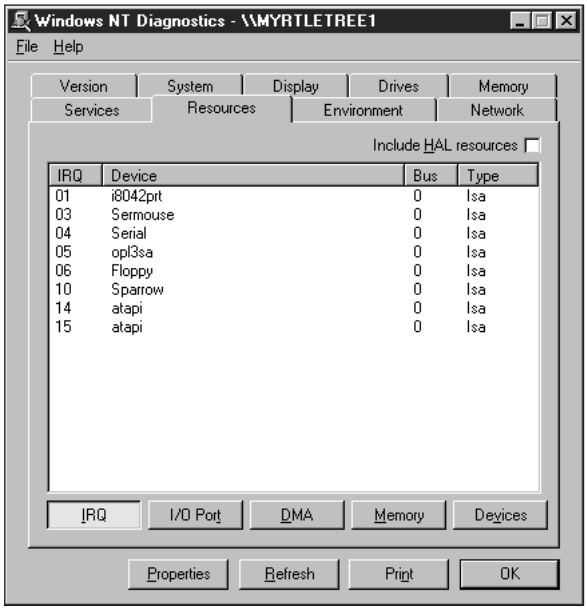

Figure 13-46 The Windows NT Diagnostics utility shows information from the registry

CHAPTER SUMMARY

- Windows NT comes in two versions, Windows NT Workstation and Windows NT Server.
- Both versions can operate on standalone PCs or on a network, but Windows NT Server can also operate as a controller in a network domain.
- The next evolution of Windows NT after Version 4 is Windows 2000.
- Windows NT does not claim to be fully backward-compatible with legacy hardware and software, as does Windows 9x.
- Windows NT requires at least a 486DX Intel-based CPU, 12 MB of RAM, and 120 MB of hard drive space.
- Windows NT is written for different CPU technologies. The installation information for three different CPU types is contained on the CD-ROM.
- The hardware compatibility list (HCL) is maintained by Microsoft and is a list of devices that, according to Microsoft, are compatible with Windows NT.
- Windows NT and Windows 9x have a similar desktop; many functions look and act the same way.
- Windows NT can operate using two different file systems: FAT16 and NTFS. NTFS offers more security and power than does FAT16, but FAT16 is backward-compatible with older OSs.

- A PC can be configured to dual boot between Windows NT and either DOS or Windows 9x.
- Windows NT works on different platforms and with different software because of its modular approach to interfacing with both.
- The two architectural modes of Windows NT are user mode and kernel mode. Kernel mode is further divided into two components: executive services and the hardware abstraction layer (HAL).
- A process is a unique instance of a program running together with the program resources and other programs it may use.
- An NTVDM provides a DOS-like environment for DOS and Windows 3.x applications.
- Windows 3.x 16-bit applications run in a WOW.
- A workgroup is a group of computers and users sharing resources. Each computer maintains a list of users and their rights on that particular PC.
- A domain is a group of computers and users that is managed by a centralized controlling database on a computer called the primary domain controller (PDC).
- Of all Windows NT accounts, the administrator account has the most privileges and rights and can create new user accounts and assign them rights.
- The NT Hardware Qualifier is on the Windows NT CD-ROM and can be used to survey the hardware devices on a PC to determine if they qualify to run under the Windows NT OS.
- Four disks are important to recover from a failed Windows NT boot. Three disks are required to boot Windows NT, and an emergency repair disk (ERD) can be prepared to recover critical system files on the hard drive.
- The Windows NT Registry is a database containing all the hardware, software, and user configuration information on the PC. The Registry is stored in five files called hives.
- Windows NT makes most changes to the Registry when you change the system configuration from the Control Panel.
- Three diagnostic utilities included with Windows NT are the Event Viewer, Windows NT Diagnostics, and the Task Manager.

KEY TERMS

32-bit flat memory mode — A protected processing mode used by Windows NT to process programs written in 32-bit code early in the boot process. NT is a full 32-bit OS.

Administrator account — An account that grants to the administrator(s) rights and permissions to all hardware and software resources, such as the right to add, delete, and change accounts and to change hardware configurations.

API (application program interface) — A method used by an application program to call another program to perform a utility task.

Backup domain controller (BDC) — A computer on a network that holds a read-only copy of the SAM (security accounts manager) database.

Boot loader menu — A startup menu that gives the user the choice between Windows NT Workstation Version 4.0 and another OS, such as Windows 98.

Boot partition — The hard drive partition where the Windows NT OS is stored. The system partition and the boot partition may be different partitions.

Configuration parameter — Another name for the value names and values of the Registry; information in the Windows NT Registry.

Domain — A logical group of networked computers, such as those on a college campus, that share a centralized directory database of user account information and security for the entire domain.

Dual boot — The ability to boot using either of two different OSs, such as Windows NT and Windows 98. Note that programs cannot be easily shared between Windows NT and the other OS.

Environment subsystems — A user-mode process in which a subsystem runs an application in its own private memory address space as a virtual machine. (Compare to integral subsystems.)

Event Viewer — A utility that tracks and logs events as they are performed by the applications, processes, or user actions. Accessed by clicking Start, Programs, Administrative Tools, and then selecting Event Viewer.

Executive services — In Windows NT, a subsystem running in kernel mode that interfaces between the user mode and HAL.

Fatal system error — An error that prevents Windows NT from loading. An example is a damaged Registry.

File system — The overall structure that an OS uses to name, store, and organize files on a disk. Examples of files systems are FAT16, FAT32, and NTFS.

Hardware abstraction layer (HAL) — The low-level part of Windows NT, written specifically for each CPU technology, so that only the HAL must change when platform components change.

Hardware compatibility list (HCL) — The list of all computers and peripheral devices that have been tested and are officially supported by Windows NT (see *www.microsoft.com/hcl*).

Hardware profiles — Configuration information about memory, CPU, and OS, for a PC. A PC may have more than one profile. For example, a docking station PC may have two profiles, one with and one without the notebook PC docked.

Hive — A physical segment of the Windows NT Registry that is stored in a file.

Integral subsystems — Processes used to provide services to the rest of the system and the applications the system supports. (Compare to environment subsystems.)

Kernel mode — A Windows NT "privileged" processing mode that has access to hardware components.

Minifile system — A simplified file system that is started so that Ntldr (NT Loader) can read files from either a FAT16 or an NTFS file system.

Multithreading — The ability to pass more than one function (thread) to the OS kernel at the same time, such as when one thread is performing a print job while another reads a file.

NT Hardware Qualifier (NTHQ) — A utility found on the NT installation CD-ROM that examines your system to determine if all hardware present qualifies for NT.

Ntldr (NT Loader) — Ntldr is the OS loader used on Intel systems.

NT virtual DOS machine (NTVDM) — An emulated environment in which a 16-bit DOS application or a Windows 3.x application resides within Windows NT with its own memory space or WOW (Win 16 application on a Win 32 platform). (*See* WOW.)

Portable Operating System Interface (POSIX) — A set of standards adopted to allow operating systems (such as UNIX and NT) and their applications to port from one platform to another.

Primary domain controller (PDC) — The computer that controls the directory database of user accounts, group accounts, and computer accounts on a domain.

Process — An executing instance of a program together with the program resources. There can be more than one process running for a program at the same time. One process for a program happens each time the program is loaded into memory or executed.

Roaming users — Users who can move from PC to PC within a network, with their profiles following them.

SAM (security accounts manager) — A portion of the Windows NT Registry that manages the account database that contains accounts, policies, and other pertinent information about the domain.

Subtree — One of five main keys that make up the Windows NT Registry. Examples are HKEY_CURRENT_USER and HKEY_LOCAL_MACHINE.

System partition — The active partition of the hard drive containing the boot record and the specific files required to load Windows NT.

Thread — A single task that is part of a larger task or program.

User account — The information, stored in the SAM database, that defines an NT user, including username, password, memberships, and rights.

User mode — Provides an interface between an application and an OS, and only has access to hardware resources through the code running in kernel mode.

User profile — A personal profile about the user, kept in the NT Registry, which enables the user's desktop settings and other operating parameters to be retained from one session to another.

Windows NT file system (NTFS) — A file system first introduced with Windows NT that provides improved security, disk storage, file compression, and long filenames.

Windows NT Registry — A database containing all configuration information, including the user profile and hardware settings. The NT Registry is not compatible with the Windows 9x Registry.

Workgroup — A logical group of computers and users in which administration, resources, and security are distributed throughout the network, without centralized management or security.

WOW (Win 16 on Win 32) — A group of programs provided by Windows NT to create a virtual DOS environment that emulates a 16-bit Windows environment, protecting the rest of the NT OS from 16-bit applications.

Review Questions

1. What are the two versions of Windows NT 4.0?
2. Which OS is more backward-compatible, Windows 98 or Windows NT?
3. Why can't a 16-bit device driver work under Windows NT?
4. What layer of Windows NT is responsible for interacting with hardware?
5. What is one reason that interaction with hardware is limited to only one layer of the OS?
6. Before you install Windows NT, how can you determine if all the hardware on your PC is supported by the OS?
7. What is one reason not to upgrade from Windows 98 to Windows NT?
8. What is one reason to upgrade from Windows 98 to Windows NT?
9. What two file systems are supported by Windows NT?
10. If you have Windows 98 installed on a PC using FAT32 and you are creating a dual boot with Windows NT, what must you do first?
11. If you are upgrading a PC from Windows 98 with FAT32 to Windows NT, how will having FAT32 on the hard drive change the results of the upgrade, as opposed to an installation that begins with FAT16?
12. Which is more likely to hang, or lock up, Windows NT or Windows 98?
13. How many bits are used to store a cluster number in the Windows NT NTFS file system?
14. What is the file system that is common to DOS, Windows 9x, and Windows NT?
15. What file system cannot be read by DOS or Windows 9x, but can be used by Windows NT?
16. Which file system can be read by some versions of Windows 9x, but not DOS or Windows NT?
17. Windows NT is installed using a system partition and a boot partition. Which of these partitions must be the active partition of the hard drive?
18. Which part of the Windows NT architecture makes it possible for Windows NT to port to more than one platform?
19. What are the two core components, or modes, of the Windows NT architecture?
20. Which of these two modes contains the NTVDM?
21. Why do 32-bit applications not need to reside in an NTVDM?
22. What is one function of a backup domain controller in a Windows NT domain?
23. In a Windows NT workgroup, where is access to an individual workstation on the network controlled?
24. In a Windows NT domain, where is access to an individual workstation on the network controlled?

25. If you are working from home and want to log on to a Windows NT network at your workplace, how do you get access to the network?
26. What is the first Windows NT program that is loaded and run when Windows NT is booted?
27. How many floppy disks are needed in order to boot Windows NT from disk?
28. What is the command to back up the Windows NT Registry to disk?
29. Of the five subtrees of the Windows NT Registry, which one is most important in retaining information about hardware?
30. Which subtrees contain information in the software hive?
31. In what folder is information stored by each user who logs on to the Windows NT workstation?
32. What Windows NT utility do you use to look for information about a failed event?
33. What Windows NT utility do you use to help solve problems with system resource conflicts?
34. A software developer comes to you with a problem. She has been asked to convert software that she has written for Windows 9x to Windows NT. The software consists of two 16-bit programs that work equally well under Windows 3.x and Windows 9x. She was able to convert one of the programs to a 32-bit version, but had to leave the other program in 16-bit code. Both programs run at the same time and share data in memory. However, when she runs the two programs under Windows NT, the 32-bit program cannot read data written to memory by the 16-bit program. Why not? What should she do so that the two programs can work under Windows NT?

PROJECTS

Using the Control Panel

1. Shut down and restart Windows NT and observe the number of seconds that the boot loader program waits until Windows NT is loaded. Key in the number of seconds to wait so that the number of seconds is doubled. Verify that the change is made, by rebooting. When you have verified the change, return the number of seconds to the original value.
2. Check under the Accessories and Games sections of Windows NT and install a new game or accessory. Verify that the program is installed.
3. Change the colors in the Display Properties box and verify the changes.

Troubleshooting the Boot Process

Prepare a copy of the three Windows NT setup disks and an emergency repair disk, and then reproduce one of the errors listed in Table 13-6. Use the disks to recover from the error.

Editing the Windows NT Registry

Be sure you have an updated copy of the three boot disks and the Emergency Repair Disk before editing the registry. Insert a CD-ROM that has autorun and verify that autorun is working. Then make a change to the registry to disable autorun from a CD-ROM by editing this subkey:

HKEY_LOCAL_MACHINE\System\CurrentControlSet\Services\CdRom\Autorun = 0

Use the Internet for Problem Solving

Access the *www.microsoft.com* web site for Windows NT Workstation support. Print one example of a frequently asked question and its answer.

Using the Windows NT Diagnostic Utility

1. Using Windows NT Diagnostics, print out information about memory for your PC.
2. List the IRQs currently not used by your system.
3. List the DMA channels that are currently being used, and explain how each is used.

Windows NT and 16-bit Applications

Try running a DOS utility such as MSD or SANDRA (from Chapter 1) under Windows NT. What error message do you get? Why?

Using the Internet for Research

You want to install Windows NT on a PC using a dual boot with Windows 98. The Windows 98 logical drive is using FAT32, and you want Windows NT to be able to access the data files on this logical drive. Using the Internet, look for third-party software that will allow Windows NT to read from and write to FAT32 volumes. Answer these questions:

1. What software allows Windows NT to read FAT32 volumes? How much does it cost? What URL did you use to answer the question?
2. What software allows Windows NT to read from and write to FAT32 volumes? How much does it cost? What URL did you use to answer the question?